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AFFDL-TR-72-147 – VOL. III

PROPULSION SYSTEM INSTALLATION CORRECTIONS

VOLUME III: SAMPLE CASES

W. H. BALL
THE BOEING COMPANY

TECHNICAL REPORT AFFDL-TR-72-147 – VOL. III
DECEMBER 1972

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AIR FORCE FLIGHT DYNAMICS LABORATORY
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45433

NOTICE

PROPULSION SYSTEM INSTALLATION CORRECTIONS

VOLUME III: SAMPLE CASES

W.H. BALL

FOREWORD

This report was prepared by the Research and Engineering Division, Aerospace Group, of The Boeing Company under Air Force Contract F33615-72-C-1580, "Propulsion System Installation Corrections", Project 1366. The program was conducted under the direction of the Prototype Division, Air Force Flight Dynamics Laboratory, Air Force Systems Command. Mr. Gordon Tamplin was the Air Force Program Monitor.

The program was initiated on 31 December 1971 and draft copies of the final reports were submitted for approval on 31 October 1972.

Dr. P. A. Ross was Program Manager and Mr. W. H. Ball was principal investigator during the program. Significant contributions to the program were made by the following individuals: Mr. Joe Zeeben, engine performance; Dr. Franklin Marshall, inlet and exhaust system technology; Mr. John Petit, nozzle internal performance and nozzle/afterbody drag; and Mr. Gary Shurtleff, programming.

This report contains no classified information extracted from other classified reports.

Publication of this report does not constitute Air Force approval of the report's findings or conclusions. It is published only for the exchange and stimulation of ideas.

Ernest J. Cross Jr.

Lt. Col. Ernest J. Cross, Jr.
Chief, Prototype Division
Air Force Flight Dynamics Laboratory

ABSTRACT

This report presents the results of a research program to develop a procedure for calculating propulsion system installation losses. These losses include inlet and nozzle internal losses and external drag losses for a wide variety of subsonic and supersonic aircraft configurations up to Mach 4.5. The calculation procedure, which was largely developed from existing engineering procedures and experimental data, is suitable for preliminary studies of advanced aircraft configurations. Engineering descriptions, equations, and flow charts are provided to help in adapting the calculation procedures to digital computer routines. Many of the calculation procedures have already been programmed on the CDC 6600 computer. Program listings and flow charts are provided for the calculation procedures that have been programmed. The work accomplished during the program is contained in four separate volumes. Volume I contains an engineering description of the calculation procedures. Volume II is a programmer's manual containing flow charts, listings, and subroutine descriptions. Volume III contains sample calculations and sample input data. Volume IV contains bookkeeping definitions and data correlations.

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TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Continued)

LIST OF ILLUSTRATIONS (Continued)

SYMBOLS AND NOMENCLATURE

A	Area, in^2
A_C	Inlet capture area, in^2
A_O	Local stream tube area ahead of the inlet, in^2
A_{O_I}	Free-stream tube area of air entering the inlet, in^2
$\mathcal{R}$	Aspect ratio, dimensionless
B	Velocity decay exponent, dimensionless
C	Sonic velocity, ft/sec.
C_D	Drag coefficient, $\frac{D}{qA_{REF}}$, dimensionless
C-D	Convergent-divergent
$C_{D_{ADD}}$	Additive drag coefficient, $C_{D_{ADD}} = \frac{D_{ADD}}{qA_C}$, dimensionless
$C_{D_{A_{MAX}}}$	Afterbody drag coefficient, $\frac{DRAG}{qA_{MAX}}$, dimensionless
$C_{D_{Base}}$	Base drag coefficient $\frac{(P_b - P_\infty)A_{BASE}}{qA_{MAX}}$, dimensionless
C_{D_S}	Scrubbing drag coefficient, $\frac{DRAG}{qA_{MAX}}$, dimensionless
C_{f_g}	Thrust coefficient, $\frac{F_g}{\frac{\dot{w}}{g}(V_{cp})}$, dimensionless
C_S	Stream thrust coefficient, dimensionless, (defined by Figure 48 of Volume IV)
C_V	Nozzle velocity coefficient, dimensionless
Conv.	Convergent
D	Drag, lb.; Hydraulic Diameter, $\frac{4A}{P}$, in., diameter, in.

SYMBOLS AND NOMENCLATURE (Continued)

F	Thrust, lb.
F_{g_i}	Ideal gross thrust (fully expanded), lb.
f/a	Fuel/air ratio, dimensionless
g	Gravitational constant, ft/sec^2
h	Enthalpy per unit mass, BTU/lb.; height, in.
h_{fan}	Enthalpy of fan discharge flow, BTU/lb
h_{pri}	Enthalpy of primary exhaust flow after heat addition BTU/lb
h_t	Throat height, in^2
K	Velocity decay coefficient, dimensionless
L	Length, in.
M	Mach number, dimensionless
P	Pressure, lb/in^2
P_r	Relative pressure; the ratio of the pressures p_a, and p_b corresponding to the temperatures T_a and T_b, respectively, along a given isentrope, dimensionless
P_T	Total pressure, lb/in^2
Q	Effective heating value of fuel, BTU/lb.
q	Dynamic pressure, lb/in^2
R, r	Radius, in.
S	Nozzle centerline spacing, in.
T	Temperature, °R
V	Velocity, ft/sec

SYMBOLS AND NOMENCLATURE (Continued)

W	Mass flow, lb/sec
W_{BX}	Bleed air removed from engine, lb/sec.
W_C, $\frac{W\sqrt{\theta}}{\delta}$	Corrected airflow, lb/sec.
W_f	Weight flow rate of fuel, lb/sec.
W_2	Weight flow rate of air, primary plus secondary, lb/sec.
W_8	Primary nozzle airflow rate, lb/sec.
x	Length, in.
α	Angle of attack; convergence angle of nozzle, degrees
γ	Ratio of specific heats, dimensionless
ε	Diffuser loss coefficient, $\frac{\Delta P_T}{q}$, dimensionless
η_B	Burner efficiency, dimensionless
ν	Kinematic viscosity, ft^2/sec.
ρ	Density, lb/ft^3

SUBSCRIPTS

B	Burner
b, base	Base flow region
BP	Bypass
BLC	Boundary layer bleed
btail	Boattail
c	Core (nozzle); capture (inlet)
DES	Design conditions

SYMBOLS AND NOMENCLATURE (Continued)

SUBCRIPTS

e	Boattail trailing edge
EFF	Based on effective area
ENG	Refers to engine demand
f	Fuel
g	gross
GEOM	Based on geometric area
int	Interference; internal
ip	Ideal, primary exhaust flow
jet	Exhaust flow jet
max	Maximum
min	Minimum
s	Scrubbing flow region
SPILL	Spillage
T	Total condition; throat station
t_f	Total condition, fan flow
T/O	Takeoff
t_p	Total condition, primary flow
o	Local conditions ahead of inlet
2	Compressor face station
8	Nozzle throat station
9	Nozzle exit station
18	Fan discharge throat station
∞	Free-stream condition
x	Local

SECTION I

INTRODUCTION

This document presents the results from the application of PITAP procedure to two typical aircraft configurations. The two configurations used are the Lightweight Fighter (Figure 1) and the F-4J (Figure 2). The Lightweight Fighter (LWF) in the example is a study configuration used by the Boeing Company during proposal competition, for which extensive analysis and wind tunnel test data are available for comparison with predicted results. The F-4J is also a configuration that has been extensively tested during the Exhaust System Interaction Program (Contract F33615-70-C-1449). Data from these tests are used to compare with PITAP predicted results.

The main part of the PITAP calculation procedure, which is designated as Program TEM 333, has already been programmed and is operational on the Air Force computer. This program requires as input data:

1) the engine performance characteristics in the form of tabulated data,

2) flight conditions in the form of altitude, Mach number, and power setting,

3) geometric constants describing the inlet and nozzle/afterbody,

4) tabulated data representing the performance characteristics of the inlet and the nozzle/afterbody reference drag

The first three of the above inputs are readily available for most cases. The fourth input, the inlet performance characteristics, must be generated using calculation procedures described in Volume I: Engineers Manual, use of test data or other analysis methods. The calculation procedures have not yet been programmed for automatic computation, so the discussion in this document is concerned primarily with the procedures used to predict the inlet performance characteristics used as input for the TEM 333 program. From this point on, all that remains to be done is prepare the input data, submit the program, and plot up the output results.

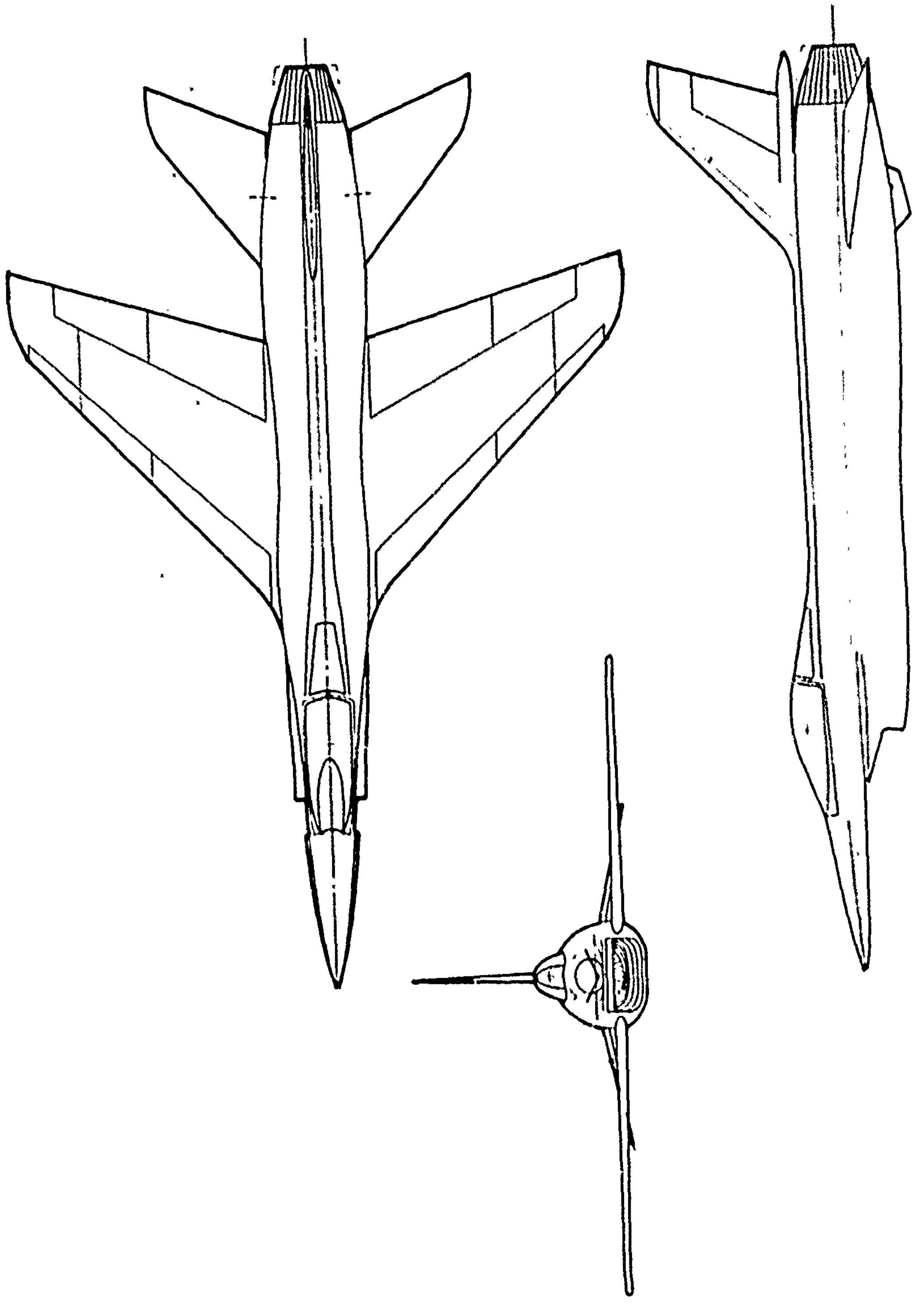


Figure 1: GENERAL ARRANGEMENT DRAWING OF LIGHTWEIGHT FIGHTER STUDY CONFIGURATION

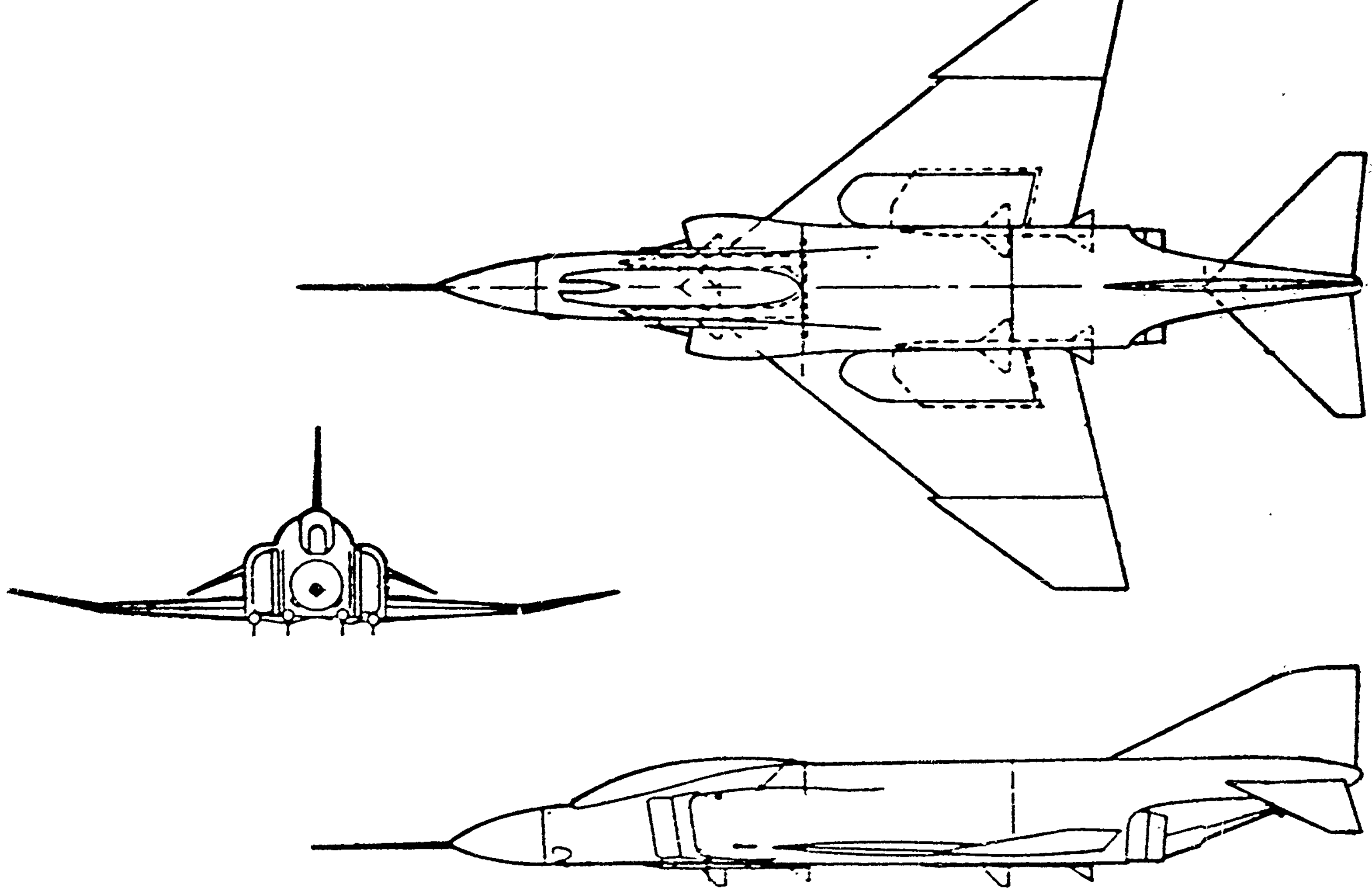


Figure 2: GENERAL ARRANGEMENT, F-4J

Installed propulsion system performance data have been calculated for both the LWF and the F-4J sample cases. Only the input and output data from the computer run for the F-4J is presented in this document however, to avoid making the document classified.

SECTION II

LIGHTWEIGHT FIGHTER SAMPLE CASE

2.1 CONFIGURATION

The general arranement of the LWF configuration is shown in Figure 1. It is a single-engine aircraft with an under-fuselage mounted inlet. The inlet is a two-dimensional, fixed geometry design with throat slot bleed. No bypass system is used. An advanced turbofan engine is used which has a variable geometry convergent-divergent exhaust nozzle.

2.1.1 Inlet

The geometric details of the inlet are shown in Figure 3. The critical areas required for analysis of the inlet performance characteristics are shown in Figure 3. These areas would normally be obtained from preliminary design drawings of the configuration or, if not available, reasonable engineering assumptions can be made.

The internal lines of the subsonic diffuser are shown in Figure 4, and the diffuser area variation is shown in Figure 5.

2.1.2 Nozzle/Afterbody

The nozzle/afterbody external geometry is shown in Figure 6. This drawing provides the dimensional data required to predict nozzle/afterbody drag. The full open nozzle position is used in calculating nozzle/afterbody reference drag.

2.2 PREDICTED PERFORMANCE CHARACTERISTICS

2.2.1 Inlet

The inlet performance characteristics which must be predicted to use as input to TEM 333 (existing program) include total pressure recovery, boundary layer bleed air drag, and spillage drag. No bypass system is used, therefore bypass drag is not predicted.

The LWF is designed to fly at speeds up to Mach 1.60, but the leading edge of the fixed 7 degree ramp has been positioned to keep oblique shocks out of the inlet up to Mach 2.0. The

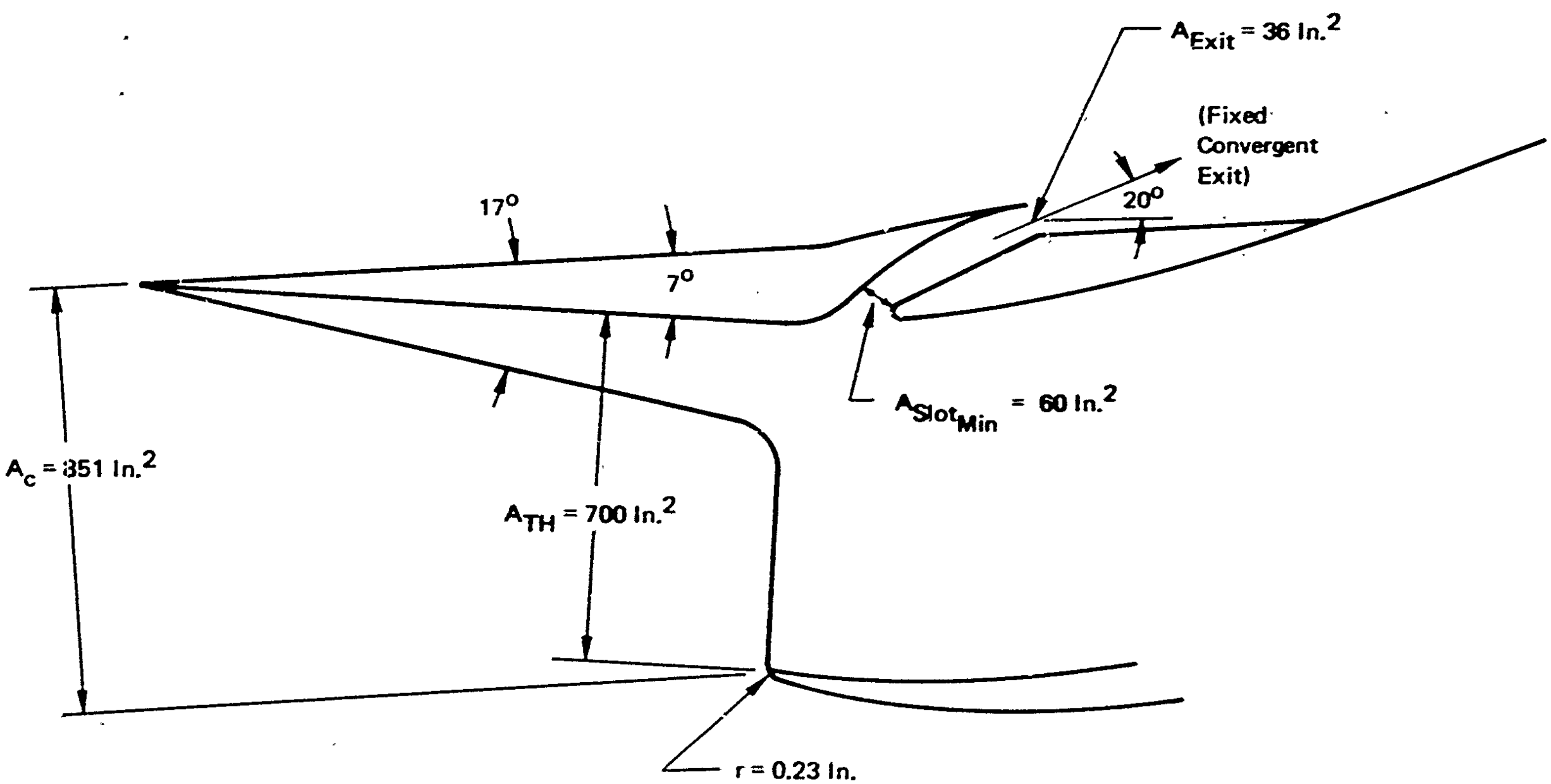


Figure 3: TWO-DIMENSIONAL INLET DETAILS

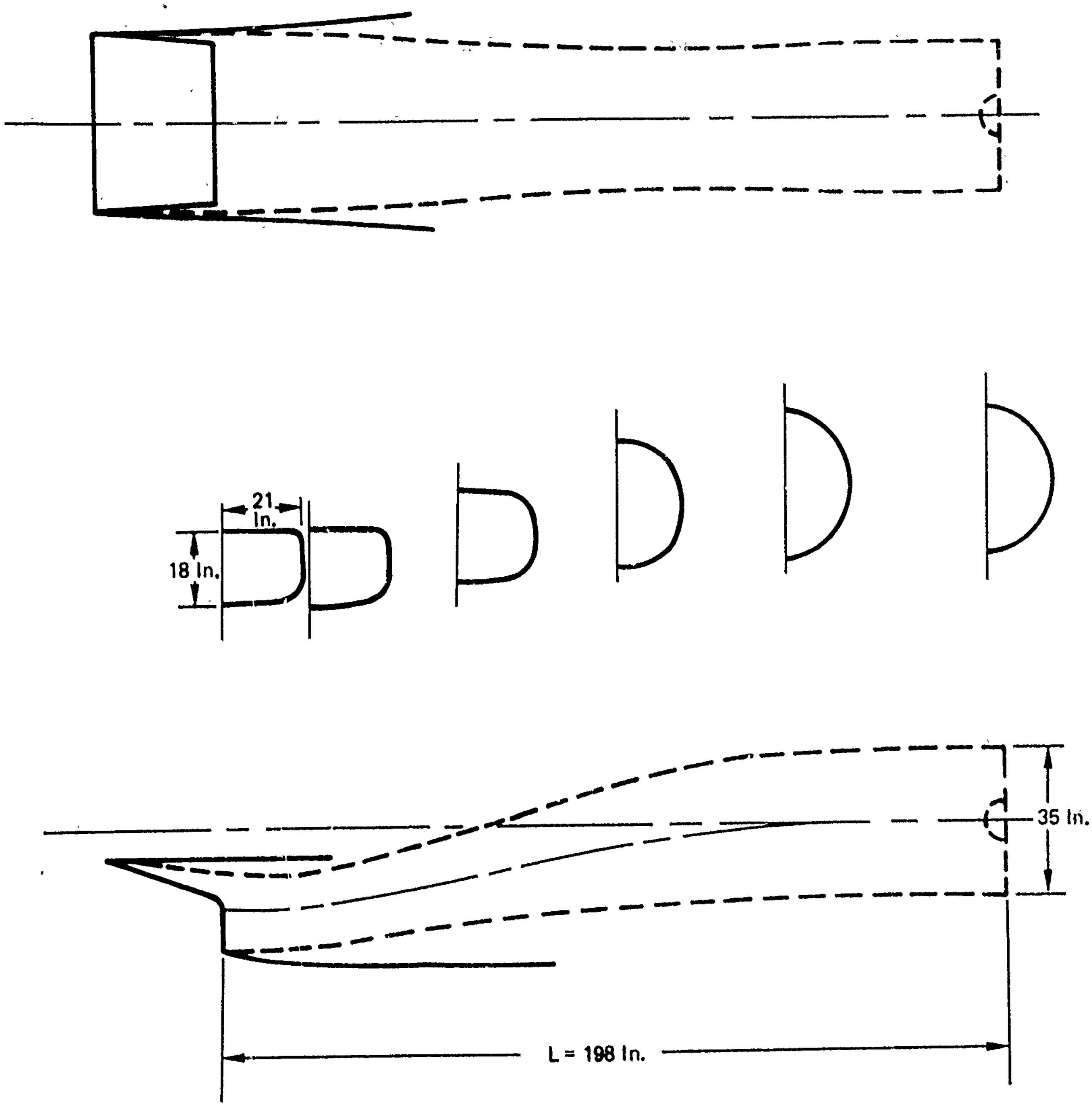


Figure 4: SUBSONIC DIFFUSER INTERNAL LINES

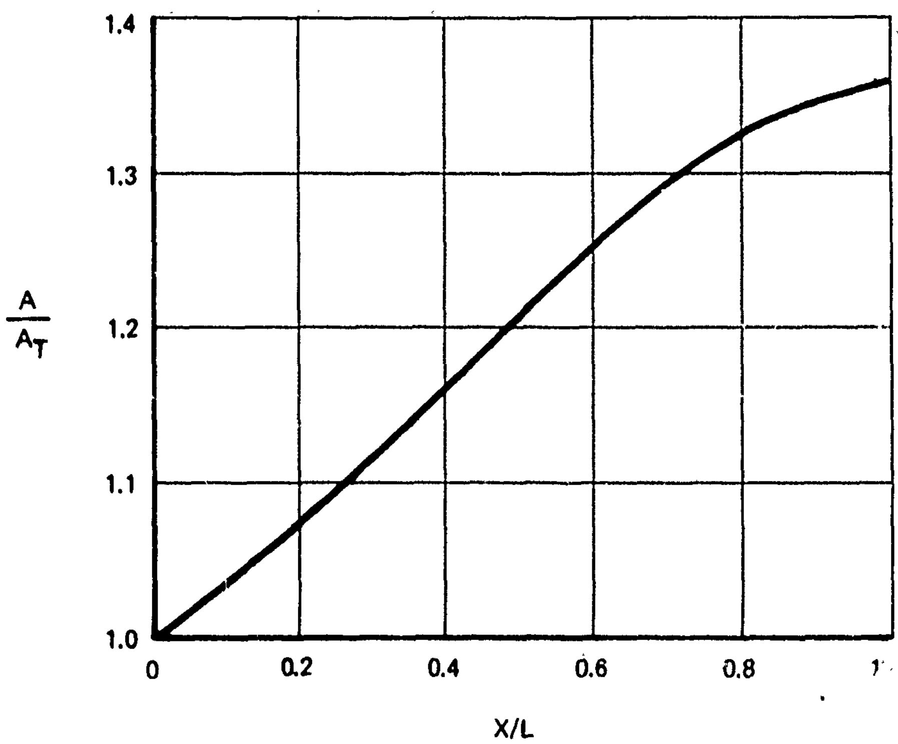


Figure 5: LWF SUBSONIC DIFFUSER AREA VARIATION

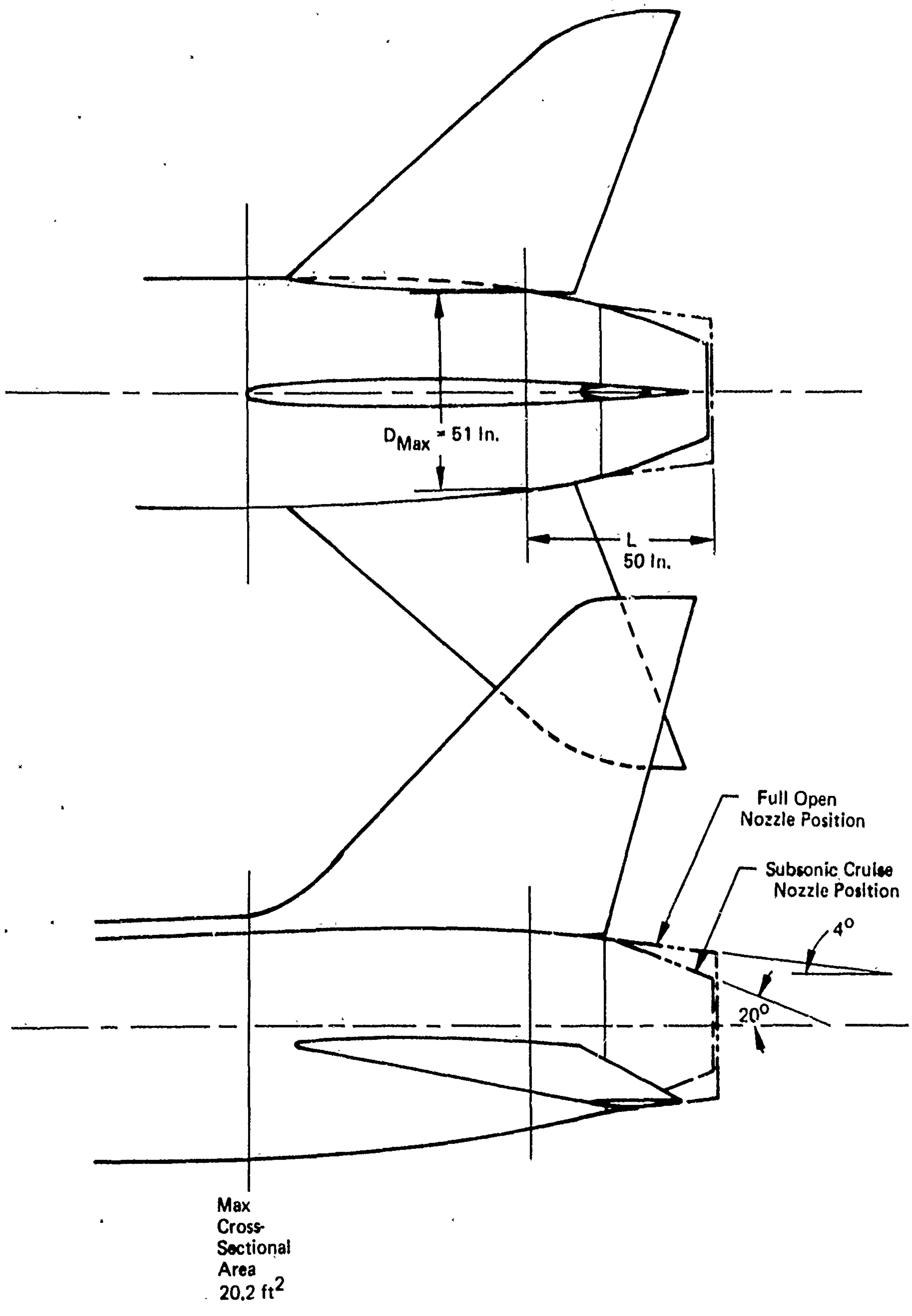


Figure 6: LWF NOZZLE/AFTERBODY EXTERNAL LINES

following flight conditions were selected for use in the analysis procedure:

M_∞ = 0, 0.2, 0.6, 0.8, 1.2, and 1.60.

The low-speed pressure recovery for the M_O = 0 and 0.20 points is estimated using the procedure in Section IV, Vol. I, beginning on page 25. The calculation proceeds as follows:

The following input quantities are obtained from known geometric data, engine data, and data correlations (Vol. IV),

$\frac{r}{D} = \frac{.23}{\left[\frac{(4)\ (700)}{(36)+(84)}\right]} = .01$		Geometric data from Figure 3
A_C	= $851\ in^2$	Geometric data from Figure 3
M_∞	= 0,.20	Specified
A_T	= $700\ in^2$	Geometric data from Figure 3
$A_{T.O.}$	= $200\ in^2$	Assumed
ε	= 0.12	Subsonic diffuser loss coefficient for subsonic flow. Average value from Figures 24 & 25, Vol. IV.

$\frac{W_2\sqrt{\theta_2}}{\delta_2}$ = Engine Airflow for M_O=0, 0.20

The above geometric and aerodynamic quantities are used as input to the low-speed calculation procedure documented in Vol. I, pages 33-41. This procedure has now been programmed as a separate subroutine, which is contained in Volume II, Programmers Manual. The results of the machine calculation are as follows:

M_O	$\frac{P_{T_2}}{P_{T_O}}$	$\frac{W\sqrt{\theta}}{\delta}$
0	0.8137	MAX
0.20	0.8937	MAX

Low-speed total pressure recovery can also be estimated from the correlation curve of Figure 20, page 33, Volume IV. The recovery values obtained using this correlation are nearly identical to the above values.

The transonic pressure recovery (M_∞= 0.6, 0.8, 1.2) is calculated from the subsonic diffuser loss coefficient and calculated throat entrance Mach number as a function of inlet airflow. Since throat Mach number is a function of engine airflow and engine airflow is a function of diffuser recovery, which depends on determine the transonic pressure recovery. This procedure is illustrated in the flow chart of Figure 16, of Volume I. Using this procedure, the following total pressure recoveries were calculated for the transonic cases:

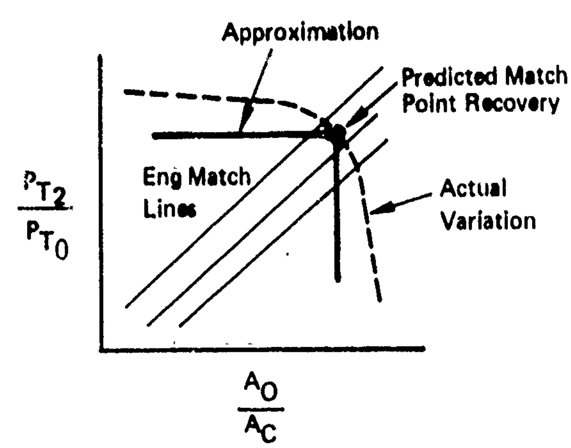
M_∞	$\frac{P_{T_2}}{P_{T_\infty}}$
0.6	0.965
0.8	0.965
1.20	0.962

The supersonic inlet total pressure recovery through the shock system at the engine-matched condition is normally obtained from the charts of Figure 17, Volume I. To these shock losses are added the total pressure recovery losses due to the subsonic diffuser. The resulting total pressure is the normal recovery at the match point as a function of free-stream Mach number. For the LWF inlet, a two-shock supersonic diffuser design, the match point shock recoveries are obtained from Figure 17, Volume I for N=2. Next, the subsonic diffuser total pressure losses, calculated using a duct loss coefficient, ε = .12 (from Figure 24 of Volume IV) and an assumed throat Mach number of .75, are added to the shock losses to obtain the design point total pressure recovery as a function of Mach number. The calculated

quantities are summarized in the following table:

M_∞	$\frac{P_{T_{NS}}}{P_{T_0}}$ (Fig. 17, Vol. I)	$\frac{P_{T_0}}{P_{T_\infty}}$ (Fig 7)	$\frac{P_{T_2}}{P_{T_1}}$ (Fig. 15, Vol. I)	$\frac{P_{T_2}}{P_{T_\infty}}$
1.0	1.0	1.0	0.9625	0.9625
1.2	0.99	1.0	0.9625	0.952
1.4	0.982	1.0	0.9625	0.945
1.6	0.968	1.0	0.9625	0.93

The above recovery values can be used for most preliminary design studies where performance is required at design point conditions over a range of flight Mach numbers. To fit the format of the TEM 333 program however, it is necessary to specify recovery as a function of engine-plus-bypass mass flow ratio, A_0/A_C. This can be accomplished by using the design point recovery values calculated above as constants which do not change with mass-flow ratio below the design point and which drop straight down form the design match point. This results in a series of recovery vs. mass flow ratio plots which are different from the actual variations as shown by the following sketch:



The above method does not result in large errors for engine match lines are near the match point. However, it can result in predictions of recovery that are slightly low for off-design

airflow demands. To demonstrate the use of an alternate recovery predicting method that can be used to improve on the recovery variations at off-design mass flow ratios, an existing computer program (Reference 1), available to industry, was used for the LWF sample case, as an aid in calculating off-design recoveries. This computer program, which was originally designed to calculate theoretical additive drag, also calculates the inviscid total pressure recovery through two-shock inlet systems. The program also calculates the mass flow spilled over sideplates of various amounts of cutback. The existing version of the program, however, does not take into account the effect of the spilled mass flow on the strength of the normal shock. It is necessary, therefore, to make an adjustment to the machine computed values of inlet lip total pressure recovery to account for this effect. This approach was used for the LWF sample case. It was assumed that the airflow spilled over the sideplates resulted in a directly proportional increase in A/A* of the supersonic flow ahead of the normal shock. The new Mach number corresponding to this A/A* was used to obtain the normal shock total pressure recovery. The inlet lip Mach numbers from the program (as a function of mass flow ratio, A_{O_I}/A_C) were then used with a subsonic diffuser loss coefficient of 0.12 to obtain overall total pressure recovery, P_{T_2}/P_{T_O}, as a function of inlet mass flow ratio. Using the above described methods the plotted data shown in Figure 8 were obtained for Mach numbers 1.20 and 1.60. The subsonic values for M_O = 0.60 and 0.80 obtained from the previously described calculation program are also shown in the same plot for the sake of completeness. Various engine airflow demand match lines are also shown in Figure 8 to indicate where the inlet/engine combination will actually operate. The matched recovery and mass flow as a function of local inlet Mach number are shown in Figures 9 and 10 respectively. Approximate inlet buzz and stall limits are input into the TEM 333 program to give indications of those operating points where inlet/engine compatibility problems may be likely to occur. These are not required to obtain performance data, and the calculations will not be stopped if one of the limits is exceeded, however, they do serve to point out possible problem areas. The buzz and stall limits shown in Figures 11 and 12 respectively, were obtained from trends in experimental data. If reliable buzz and stall limits cannot be obtained, the best available estimate should be made, by selecting appropriate points from the recovery vs. mass flow ratio plots of Figure 8.

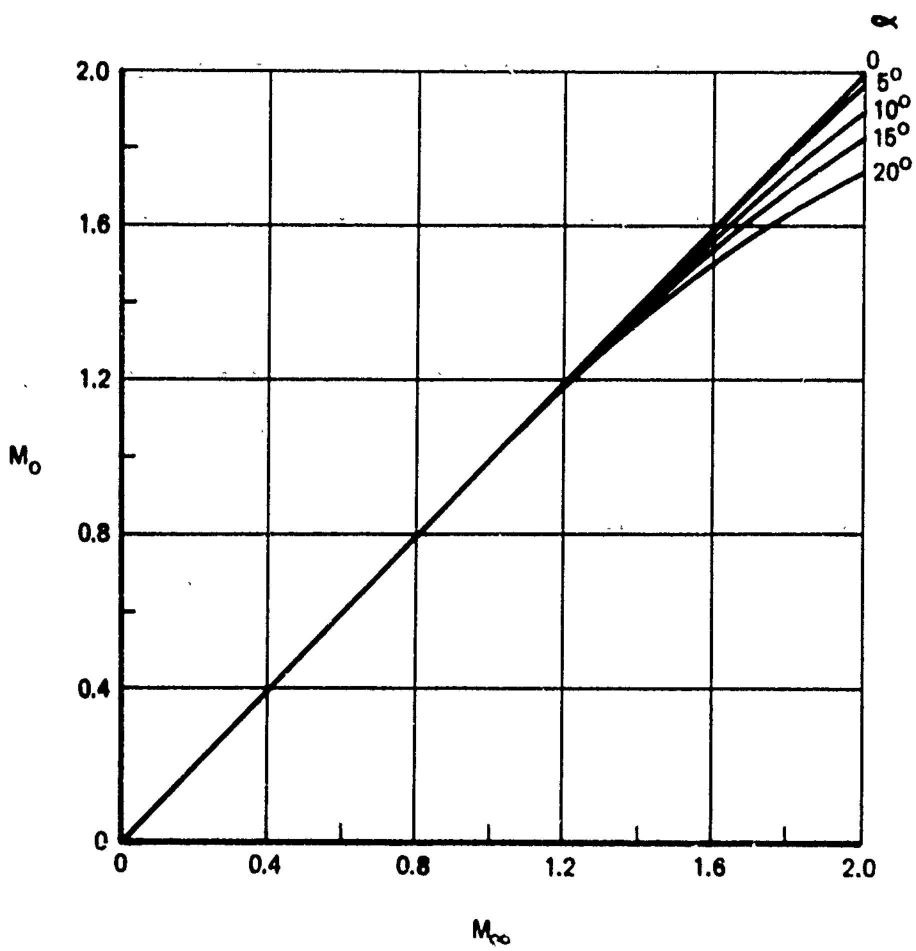


Figure 7: LOCAL MACH NUMBER VS FREE-STREAM MACH NUMBER FOR LWF

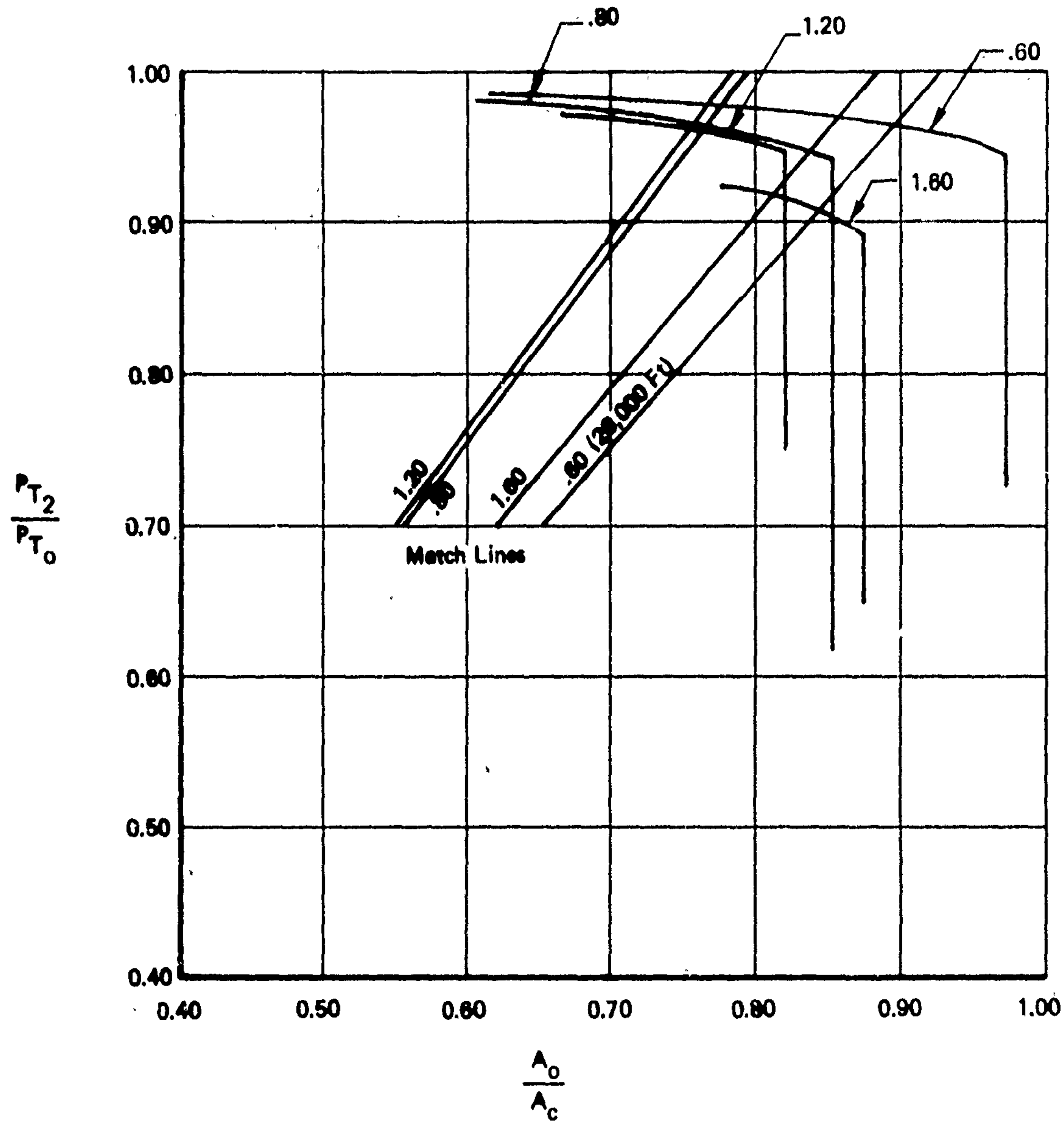


Figure 8: LWF RECOVERY VS MASS FLOW

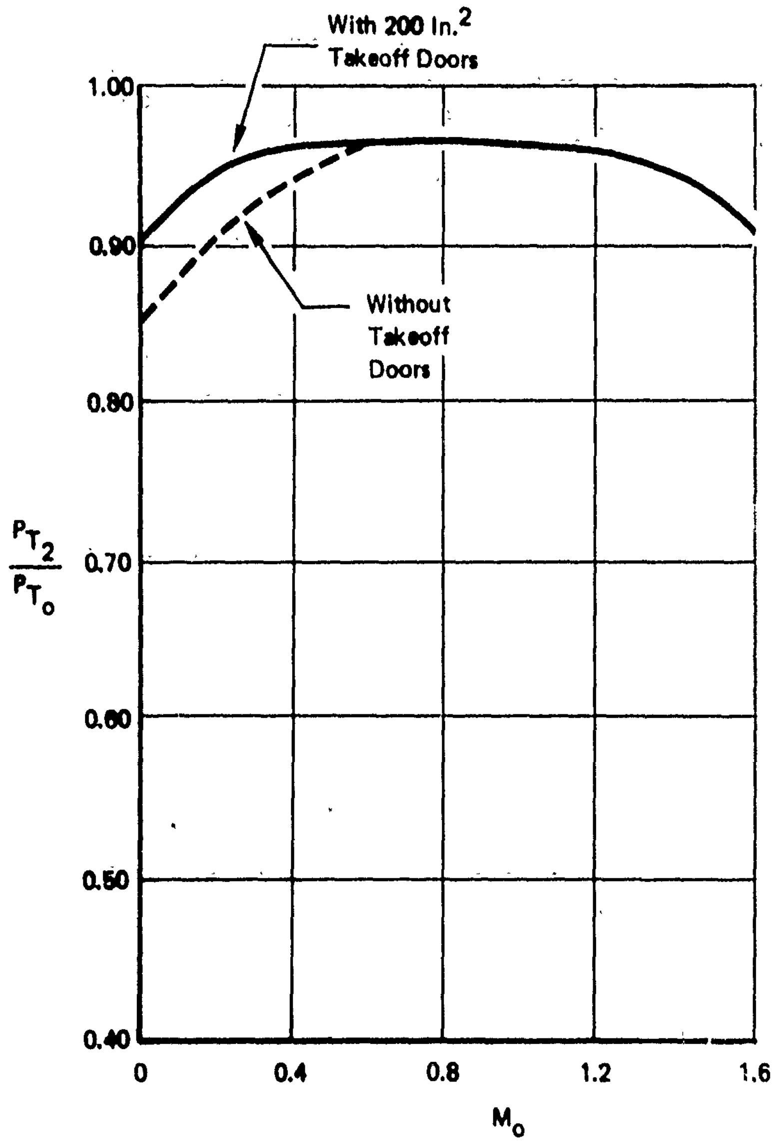


Figure 9: MATCHED INLET RECOVERY

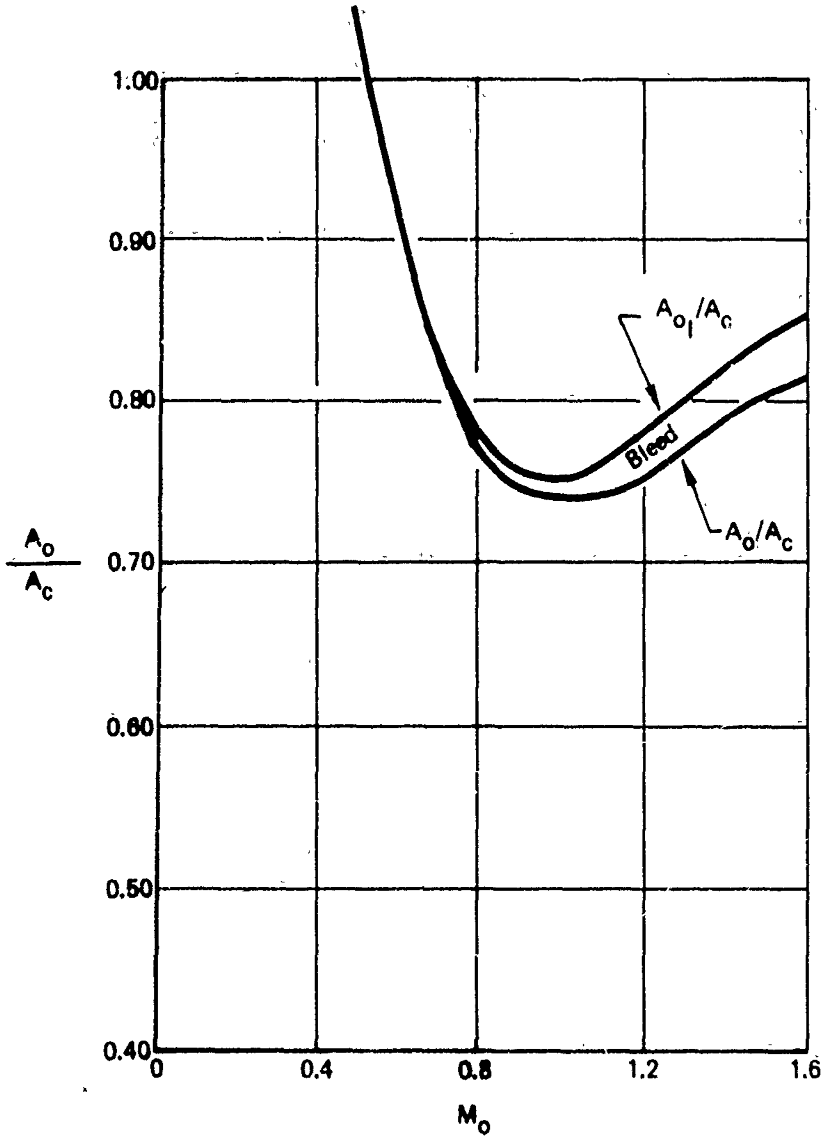


Figure 10: MATCHED MASS FLOW

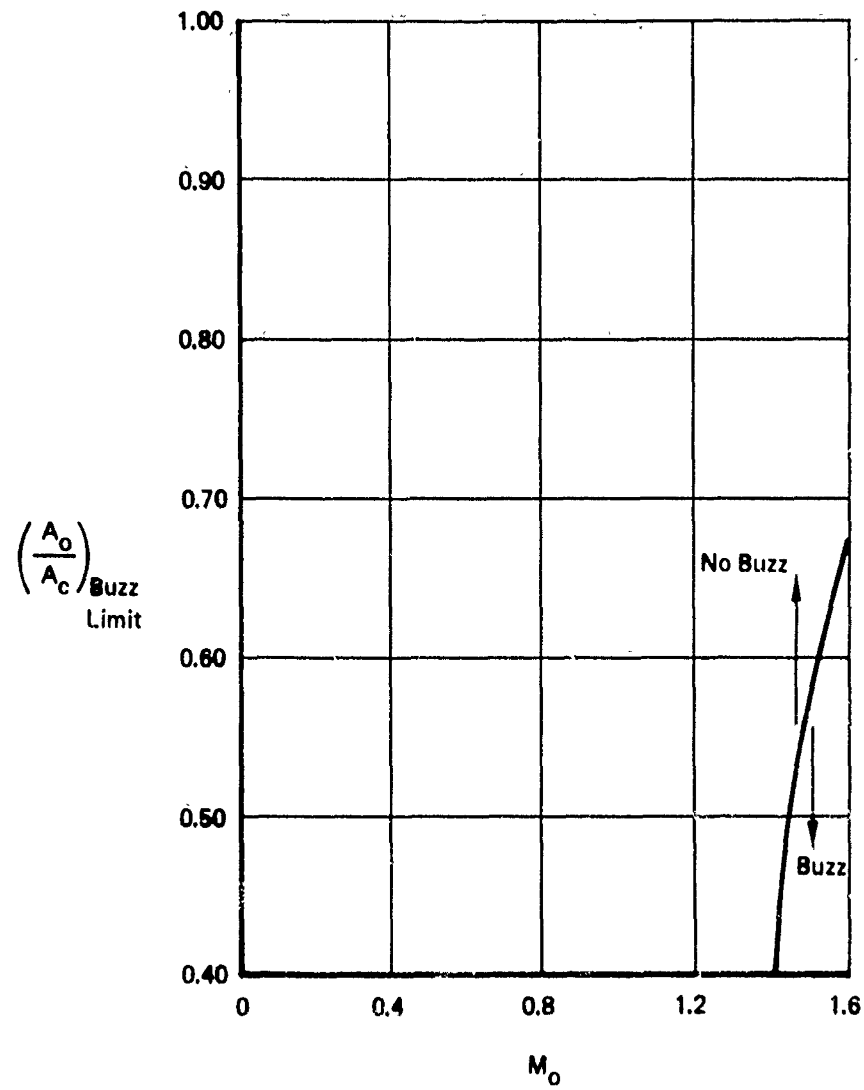


Figure 11: BUZZ LIMIT

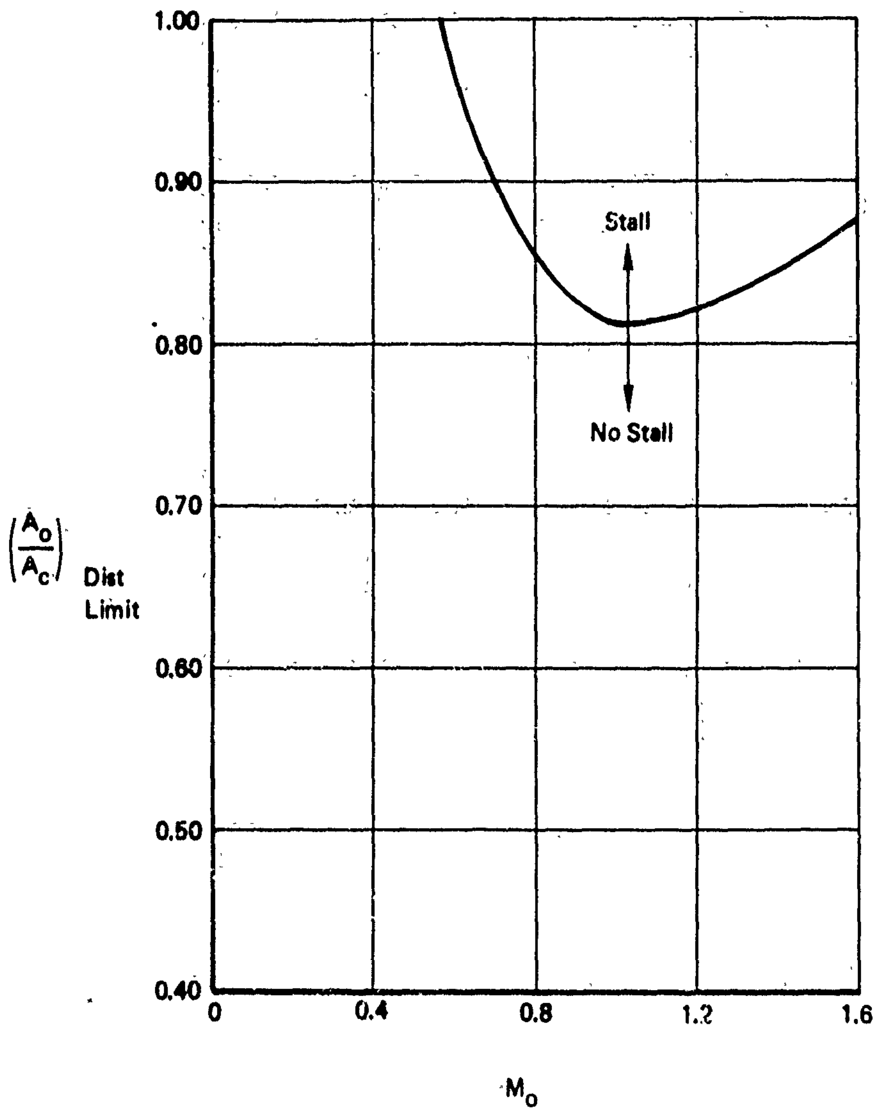


Figure 12: DISTORTION LIMIT

The first step in calculating the inlet drag is to establish an appropriate baseline mass flow ratio for use in bookkeeping aero and propulsion forces on the airplane. For subsonic Mach numbers, the baseline mass flow ratio is chosen as $\left(\frac{A_{O_I}}{A_C}\right)_{Ref} = \frac{A_T}{A_C}$. For supersonic Mach numbers, the baseline mass flow ratio is chosen as $\left(\frac{A_{O_I}}{A_C}\right)_{Ref} = \left(\frac{A_O}{A_C}\right)_{MAX}$ for each Mach number.

The maximum supersonic operating mass flow ratios for the LWF were obtained by use of the previously described computer program of Reference 1. The resulting baseline mass flow as a function of free-stream Mach number is shown in Figure 13.

The spillage drag calculation for the LWF was initiated by using the additive drag program of Reference 1 to calculate theoretical additive drag as a function of free-stream Mach number and inlet mass flow ratio. After the calculated additive drag was obtained, two adjustments were made:

1) The additive drags were adjusted so that the additive drag was zero at the baseline mass flow ratio condition. This resulted in plots of $\Delta C_{D_{ADD}}$ vs. A_{O_I}/A_C.

2) Next, the $\Delta C_{D_{ADD}}$ values were multiplied by K_{ADD} factors to correct the theoretical additive drags for configuration effects. These K_{ADD} factors (Figure 14) were obtained from the data of Volume IV. Due to the limited amount of data on K_{ADD} factors it was necessary to do a considerable amount of interpolation, extrapolation, and smoothing to obtain the K_{ADD} factors shown in Figure 14.

The final spillage drag data are presented in Figure 15.

The boundary layer bleed drag was calculated using the bleed airflow shown in Figure 16 and the bleed airflow total pressure recovery shown in Figure 17. These data were obtained from Volume IV, Section IV, "Data for Specific Configurations."

The final calculated boundary layer bleed drag is presented in Figure 18. The final bleed drag is presented as a single curve of $C_{D_{BLC}}$ vs. $\frac{A_{O_{BLC}}}{A_C}$ because there was little variation

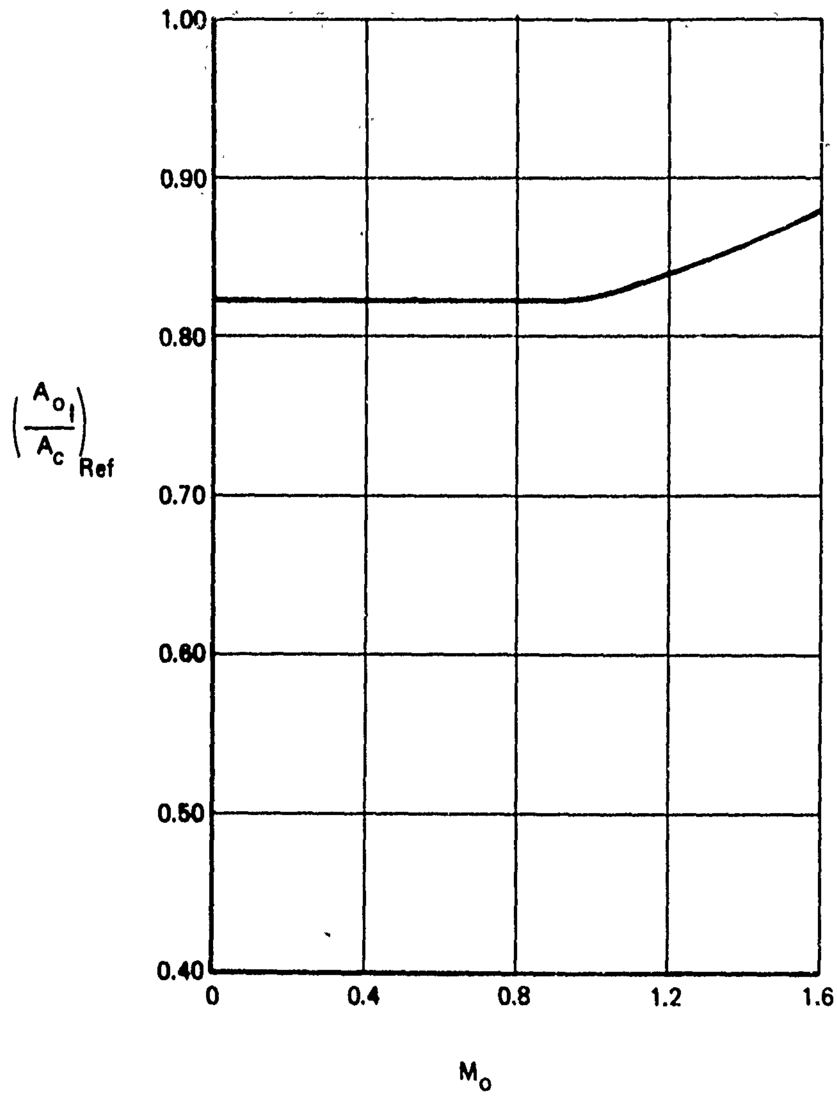


Figure 13: *REFERENCE MASS FLOW*

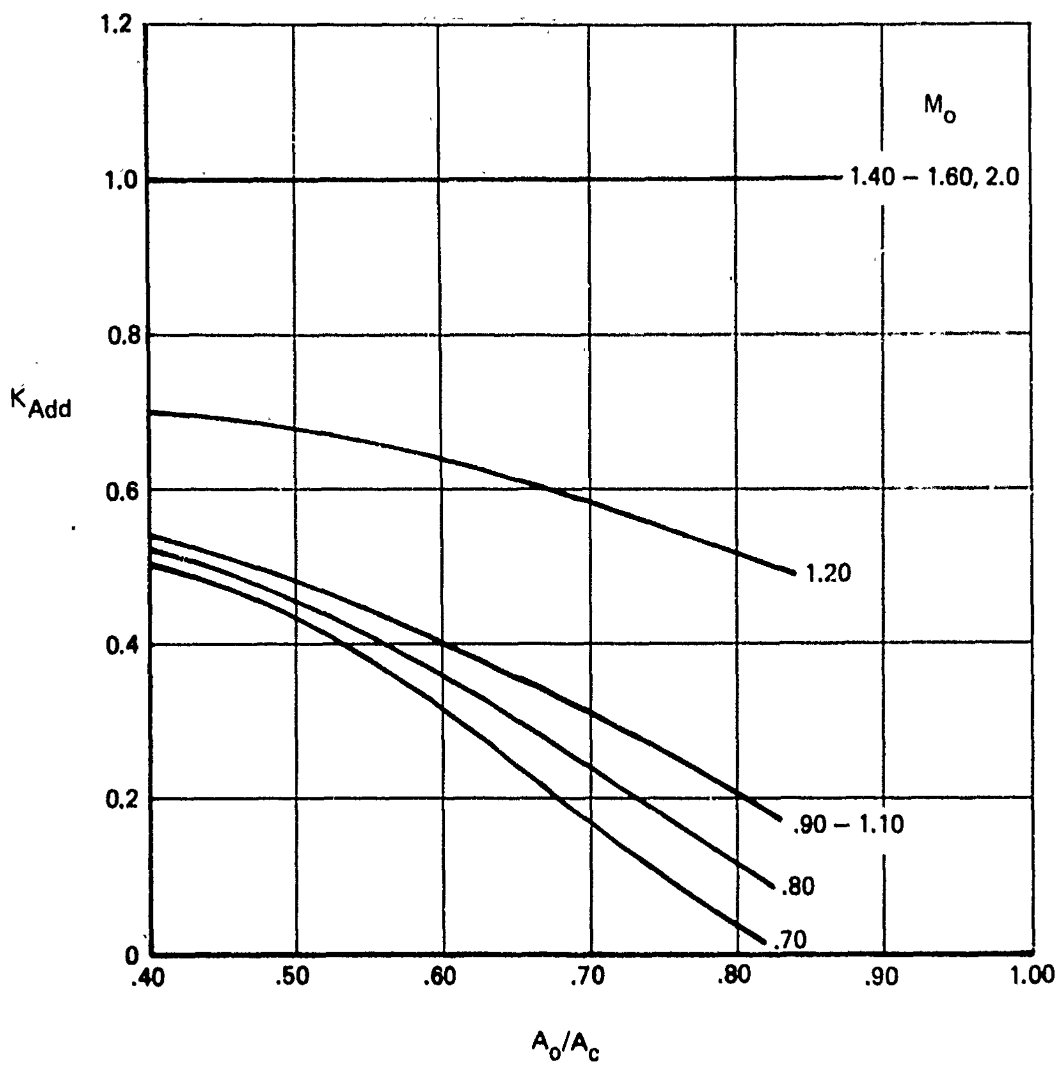


Figure 14: *K_{ADD} FACTORS FOR LWF SPILLAGE DRAG PREDICTION*

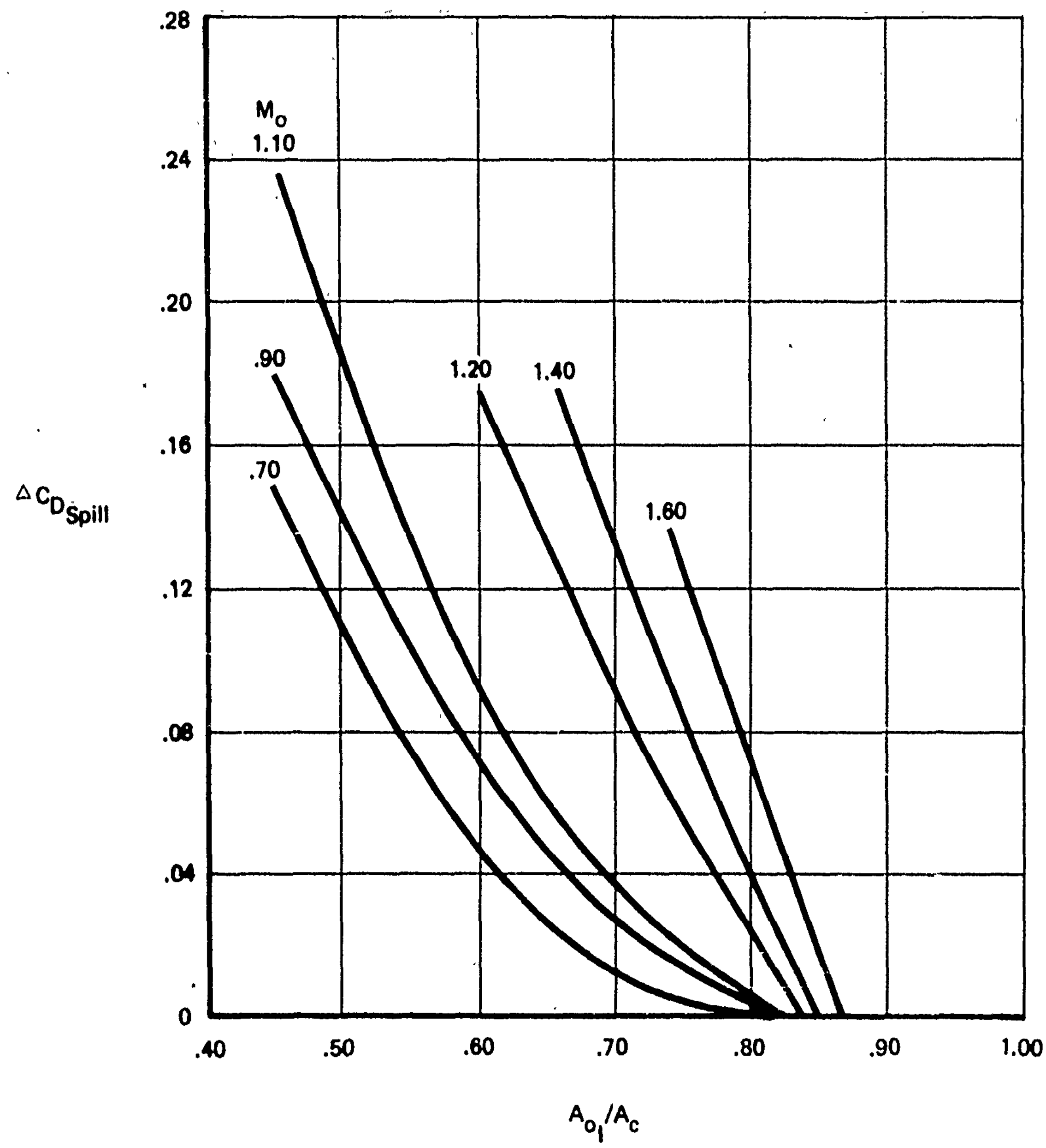


Figure 15: SPILLAGE DRAG FOR LWF

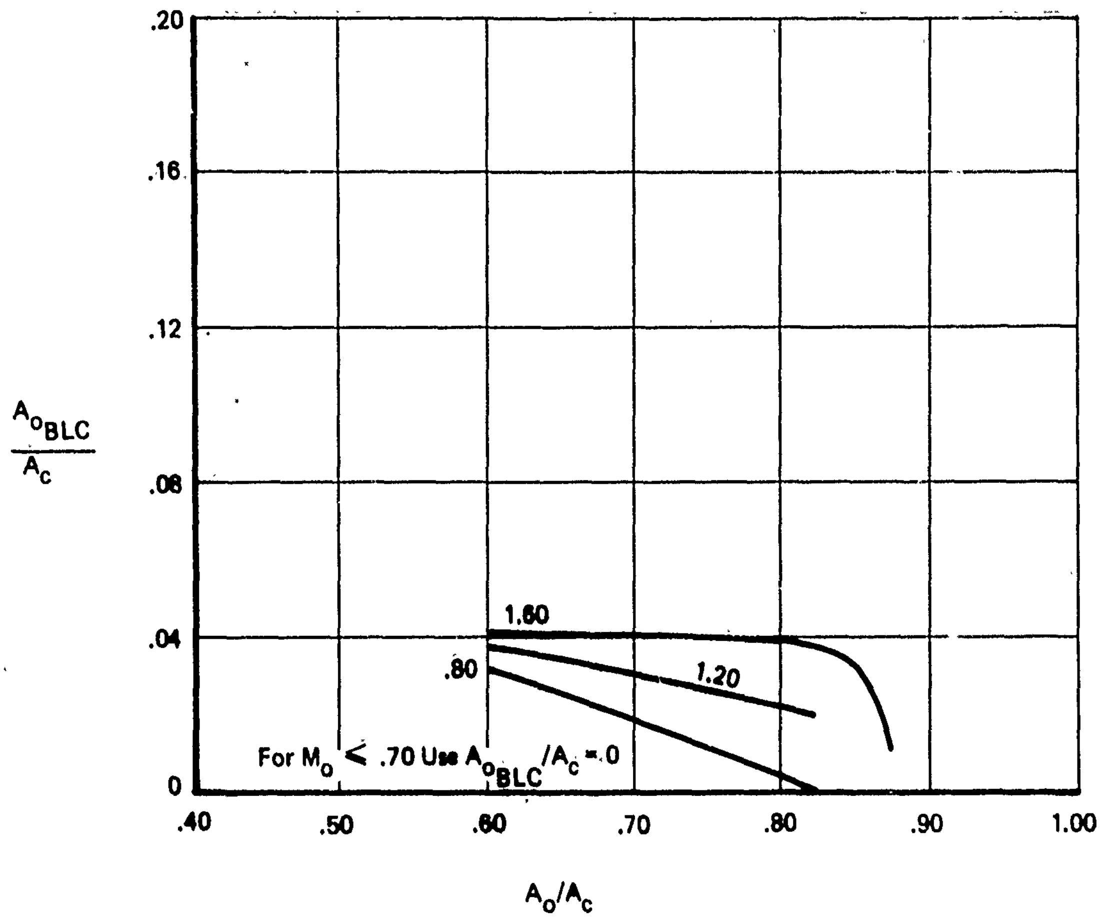


Figure 16: BOUNDARY LAYER BLEED AIRFLOW

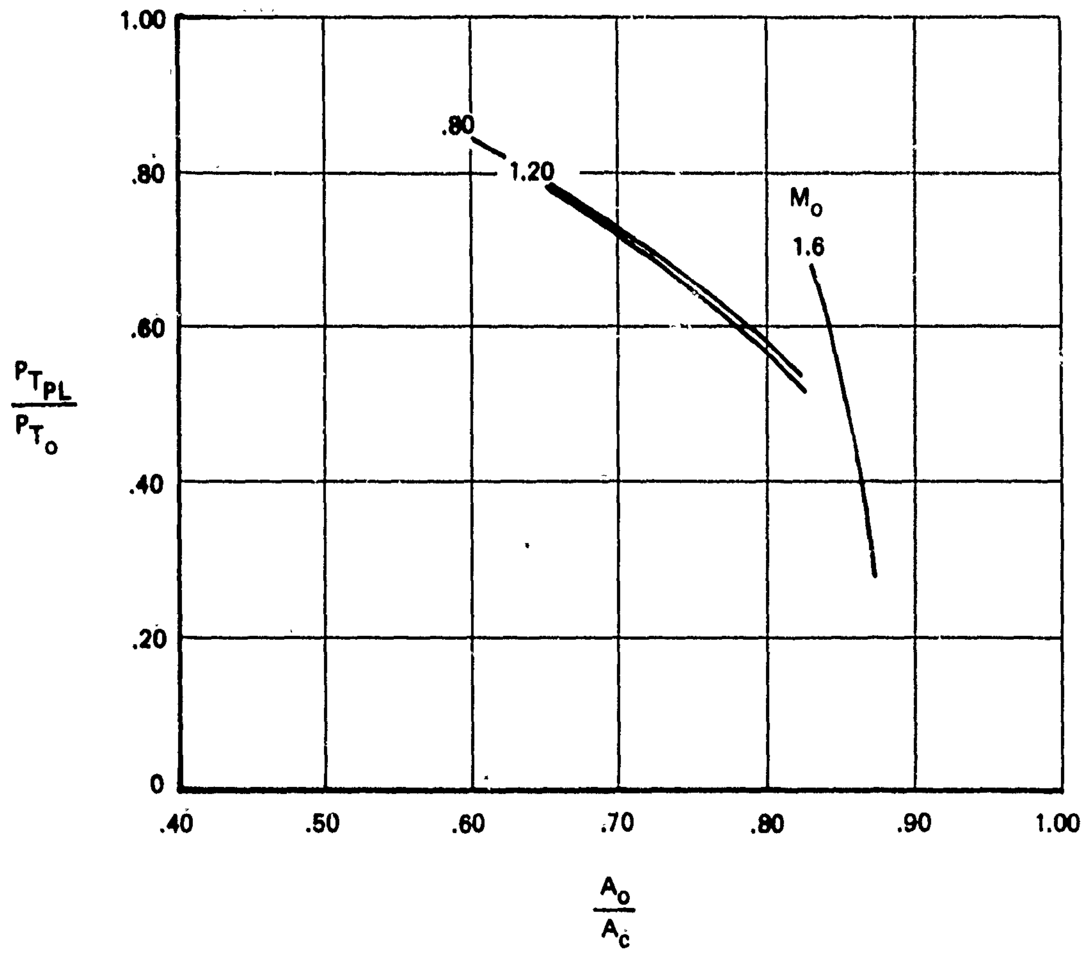


Figure 17: BOUNDARY LAYER BLEED AIRFLOW TOTAL PRESSURE RECOVERY

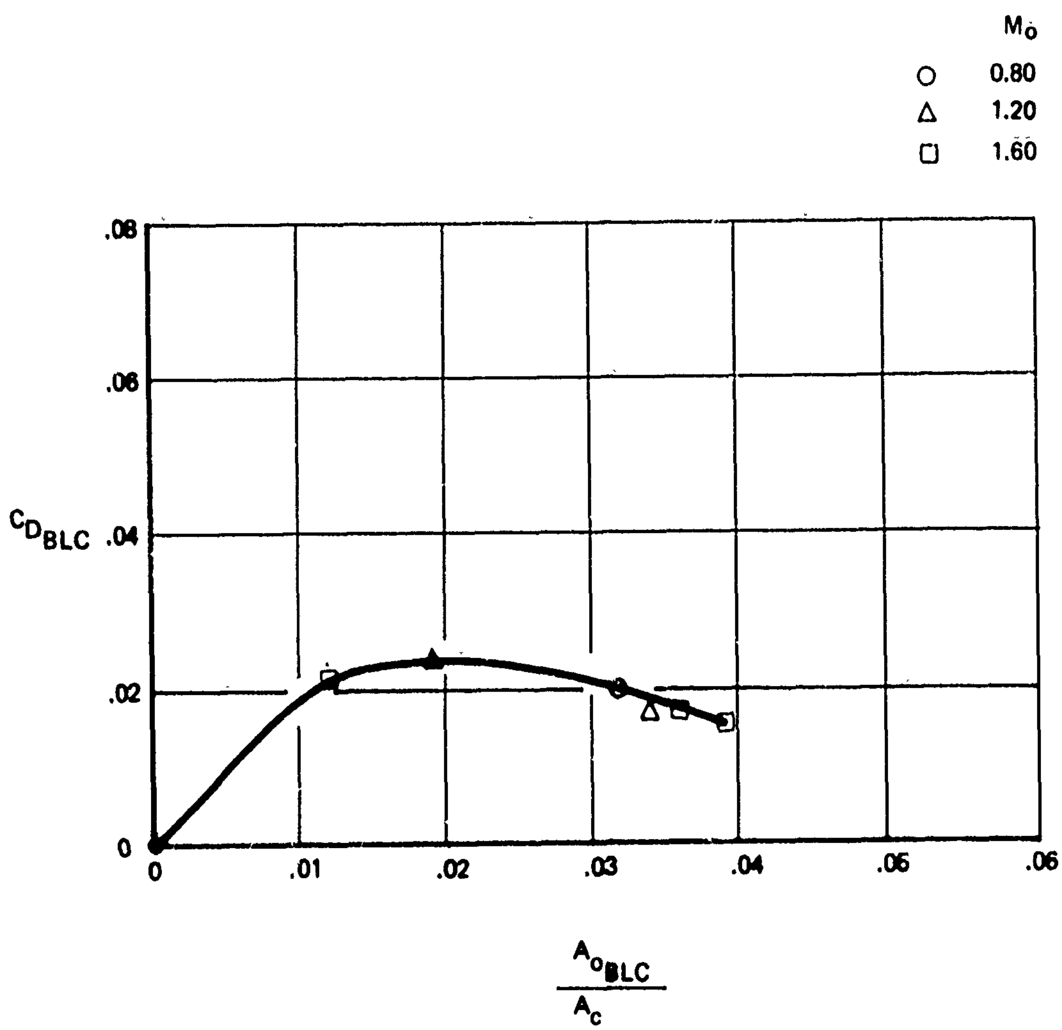


Figure 18: BOUNDARY LAYER BLEED DRAG

in the drag as a function of Mach number. Also, since the exact geometry and location of the boundary layer bleed exit was not know, the momentum drag of the boundary layer bleed air was increased by a factor of 1.25 to account for flap drag of the exit doors. This drag would normally be computed by the procedure detailed in Section IV of Volume I, if exit geometry were specified.

The drag increases to a maximum as bleed airflow is increased, then starts to decrease again. This is due to the fact that variations in bleed airflow are produced by variations in shock position. As shock position goes more supercritical, plenum pressure drops along with airflow. Conversely, as the shock goes more subcritical, the airflow goes up and so does the pressure recovery of the bleed air. These effects tend to flatten out the $C_{D_{BLC}}$ vs. $\frac{A_{0_{BLC}}}{A_C}$ curves, as shown in Figure 18.

2.2.2 Nozzle/Afterbody

The calculation procedures for computing nozzle/afterbody drag are computerized in the TEM 333 program; therefore, the sample calculations consisted of preparing the input data for the nozzle/afterbody portion of the calculation procedure and submitting the job to the computer. These input data consist of geometric constants specifying nozzle maximum diameter, D_{MAX}, nozzle boattail length, L, nozzle-to-nozzle spacing, S, and nozzle/afterbody reference drag as a function of Mach number for the reference geometry and the reference nozzle pressure ratio. The following table summarizes the LWF geometrical constants used by the nozzle/afterbody calculation procedure in the program:

GEOMETRICAL CONSTANT	VALUE
Nozzle Spacing, S	0 (Single Engine)
Nozzle Maximum Diameter, D_{MAX}	51 in.
Boattail Length, L	50 in.

The above constants are used, together with the nozzle pressure ratio (obtained internally by the computer program from the tabulated engine performance input data), to obtain

boattail drag from the curves of Figures 19 and 20.

It is also necessary to specify as part of the input data for nozzle/afterbody drag calculation, the variation of nozzle/afterbody reference drag as a function of free-stream Mach number. This reference drag is obtained from Figures 19 and 20 using the reference nozzle/afterbody geometry shown in Figure 6. The reference nozzle/afterbody boattail angle is 4 degrees (full open nozzle position). For this boattail angle, the subsonic reference drag is obtained from Figure 19 as a function of free-stream Mach number. The supersonic boattail reference drag is calculated from the equation shown in Figure 19. Since the reference boattail angle is only 4 degrees, no pressure ratio correction form Figure 20 is required. The final predicted reference drag for the nozzle/afterbody is shown in Figure 21.

2.3 COMPARISON OF PREDICTED AND TEST DATA

The calculated data have been comparedwith test results obtained from a series of aero and propulsion tests to determine their accuracy in predicting the actual inlet recovery and spillage drag and nozzle/afterbody drag.

The results of the inlet total pressure recovery comparison are shown in Figure 22. Good agreement is obtained between predicted recovery and measured recovery throughout the flight Mach number range.

A comparison of predicted and measured inlet spillage drags is presented in Figure 23. Agreement between predicted and measured drag is generally fair for most Mach numbers, and is probably adequate for preliminary studies, however, the limited amount of data available, and the scatter in the data, from which to select the K_{ADD} factor, made it necessary to spend considerable time in arriving at a suitable set of K_{ADD} factors to use. This situation could be considerably improved by the systematic gathering and analyzing of an extensive body of drag data over a wide range of configurations.

The results of nozzle/afterbody drag predictions for a 20 degree boattail angle nozzle are compared with measured data over a Mach number range from 0.40 to 1.60 in Figure 24. The predicted drags are somewhat low subsonically and slightly high supersonically. Figure 25 presents results comparing measured and predicted subsonic nozzle drags as a function of nozzle pressure ratio for a 20 degree boattail angle nozzle.

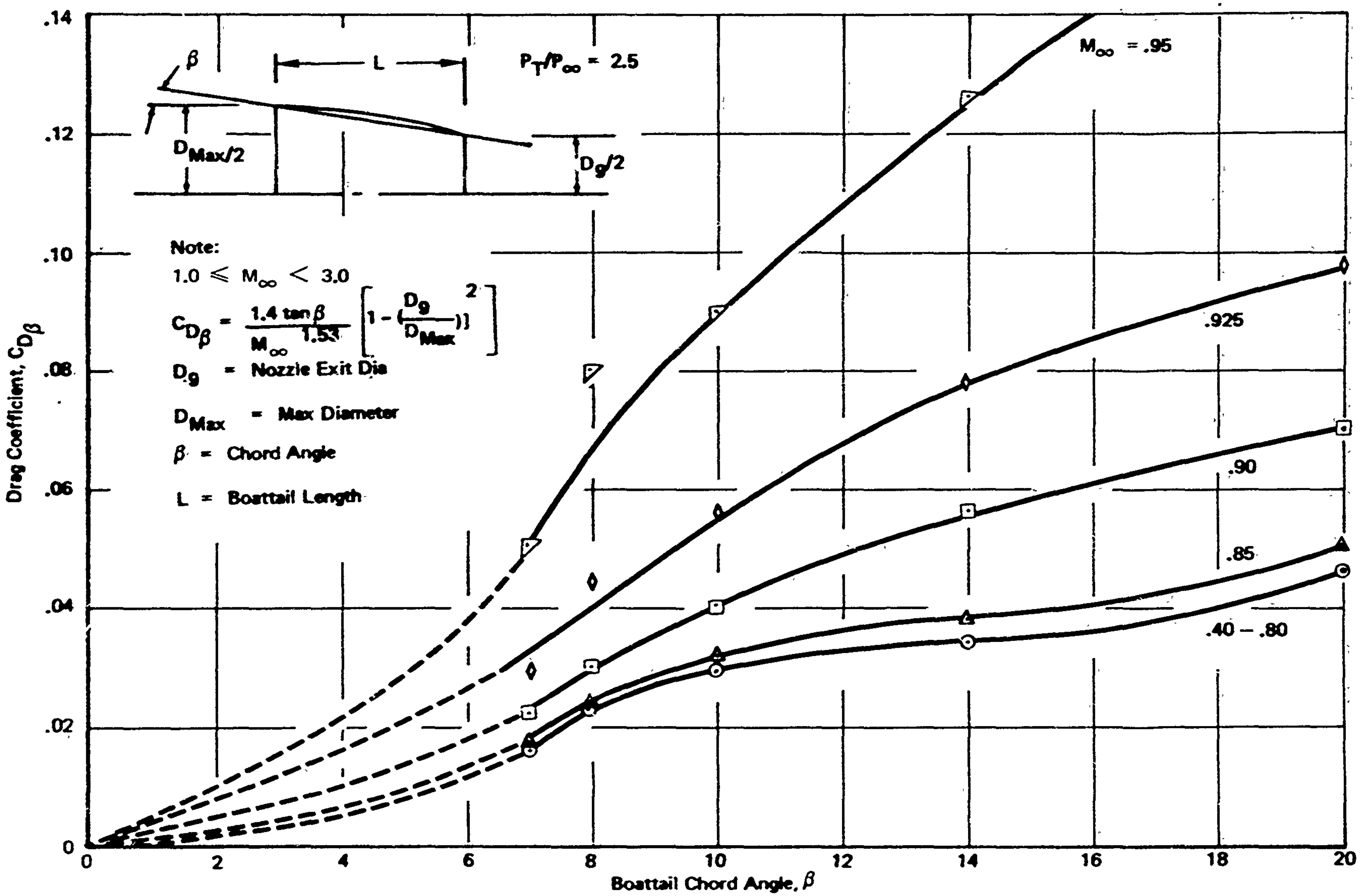


Figure 19: NOZZLE BOATTAIL PRESSURE DRAG COEFFICIENTS AS f (β)

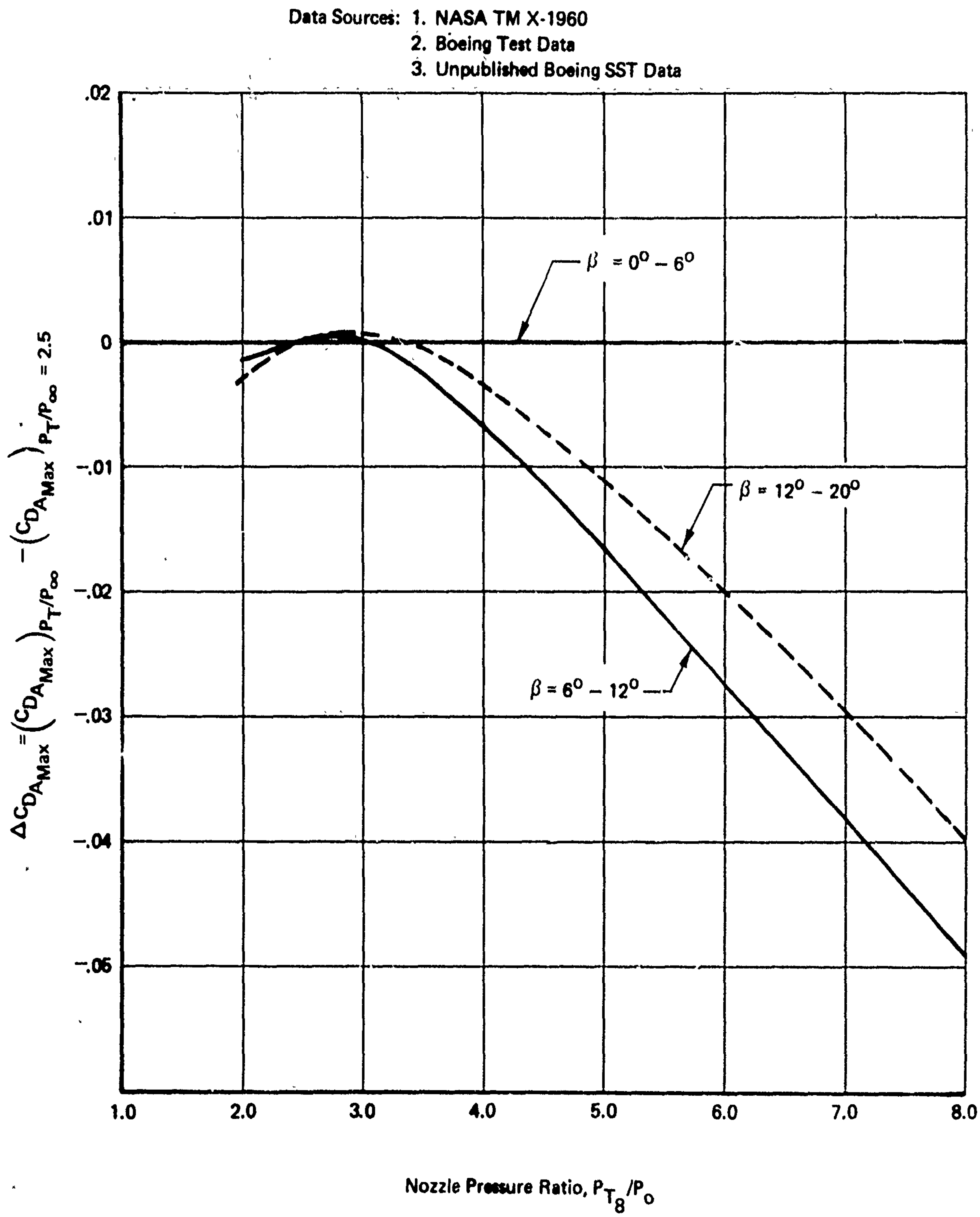


Figure 20: BOATTAIL DRAG CORRECTION FOR NOZZLE PRESSURE RATIOS OTHER THAN $P_T/P_\infty = 2.5$

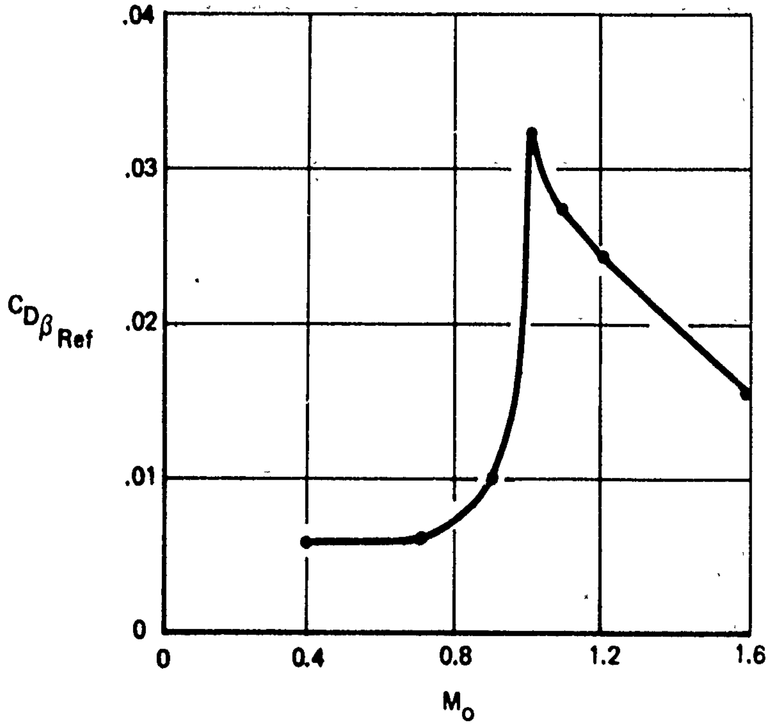


Figure 21: *LWF REFERENCE DRAG FOR NOZZLE/AFTERBODY*

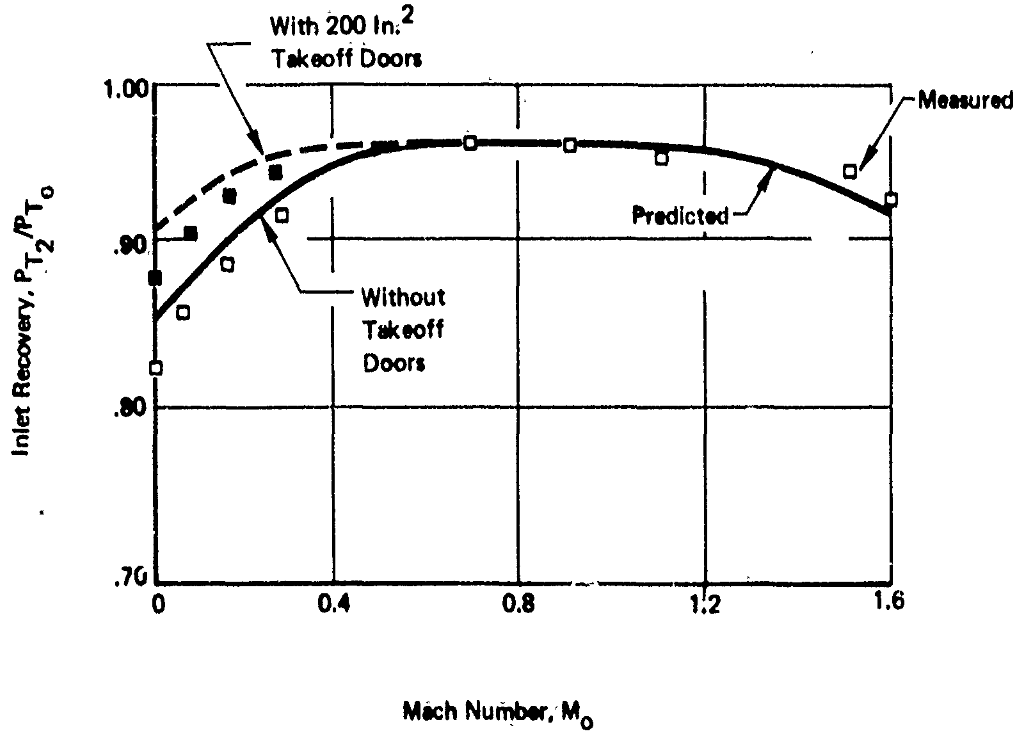


Figure 22: ***COMPARISON OF PREDICTED AND MEASURED INLET RECOVERY***

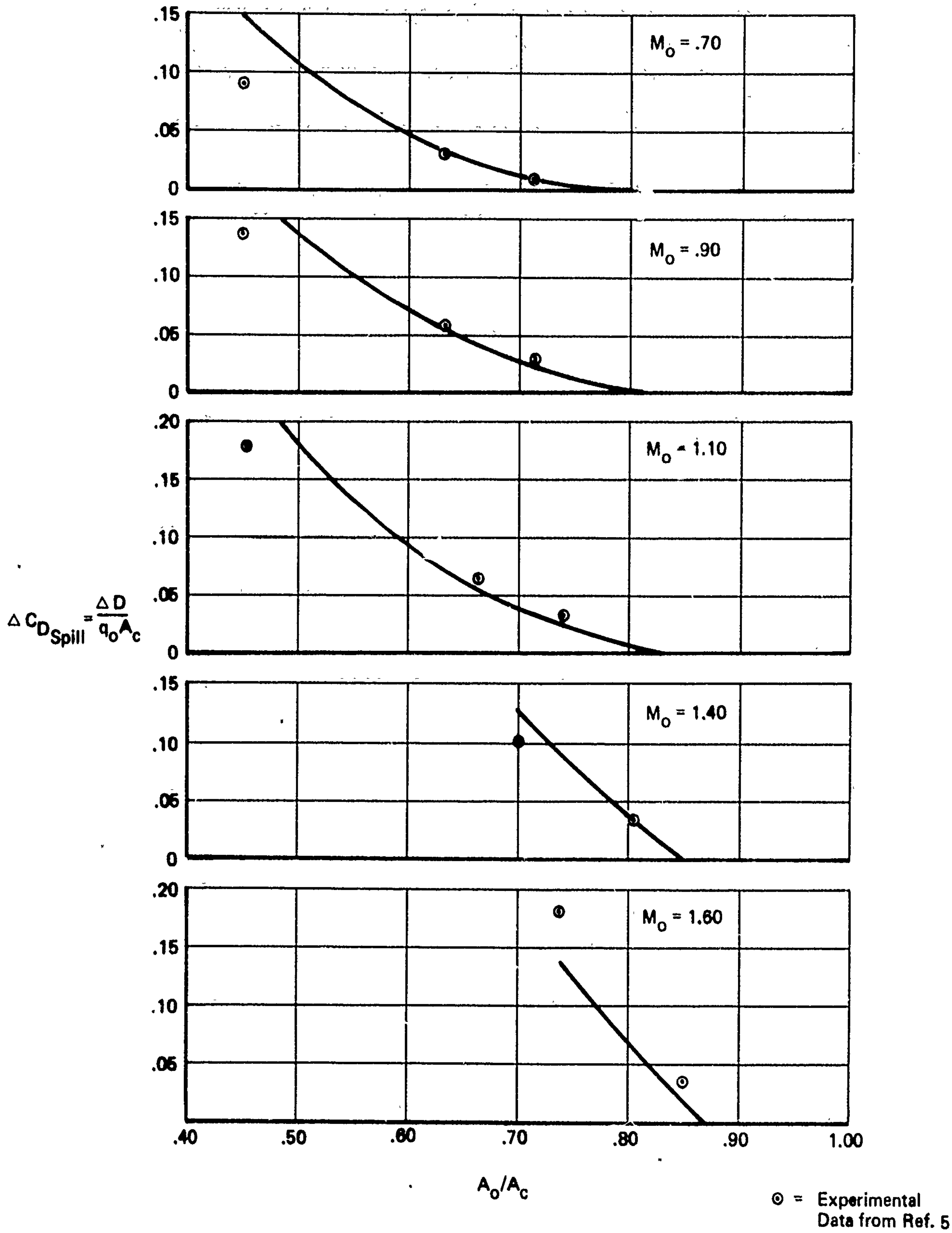


Figure 23: ***COMPARISON OF PREDICTED DATA AND TEST DATA FOR LWF SPILLAGE DRAG***

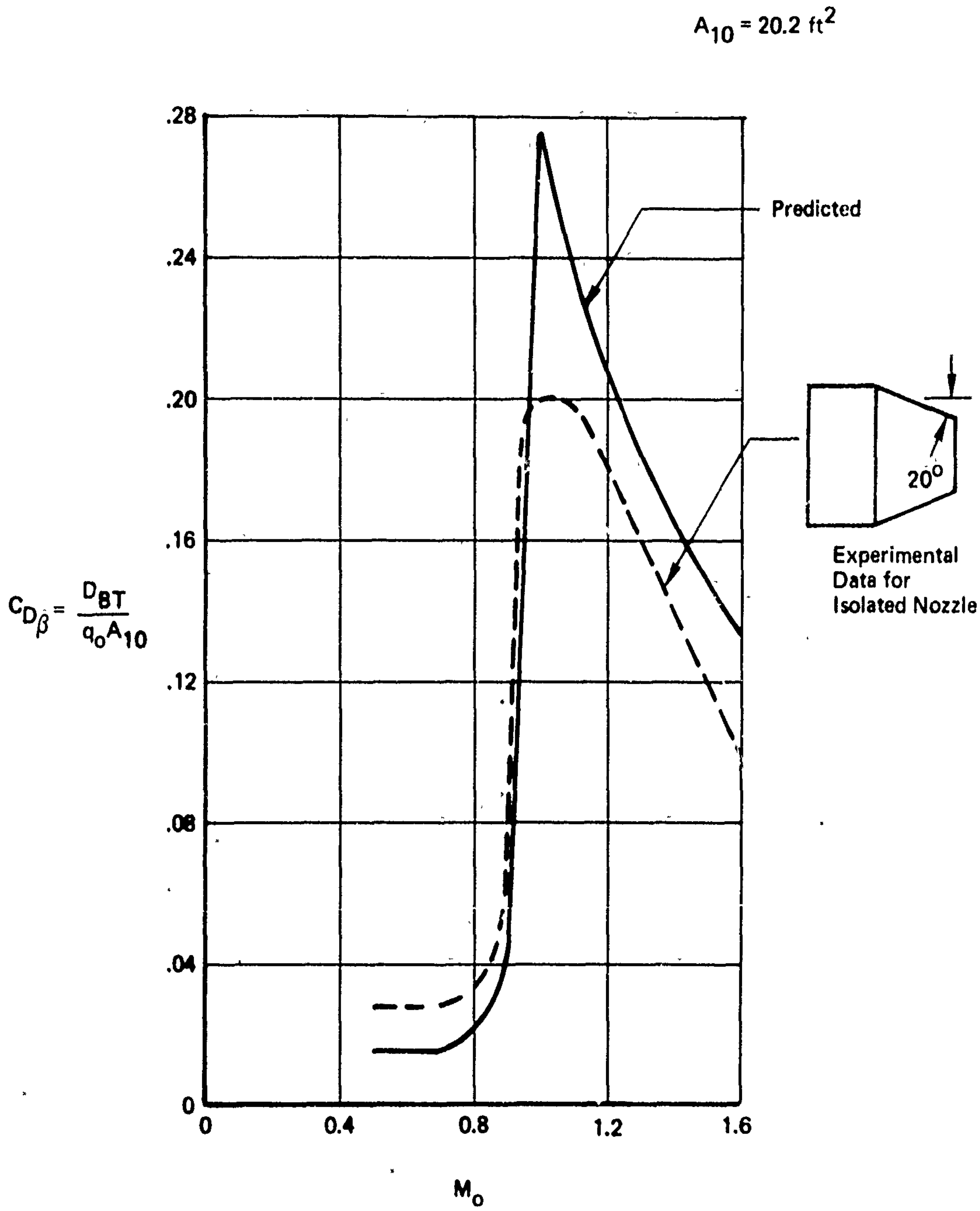
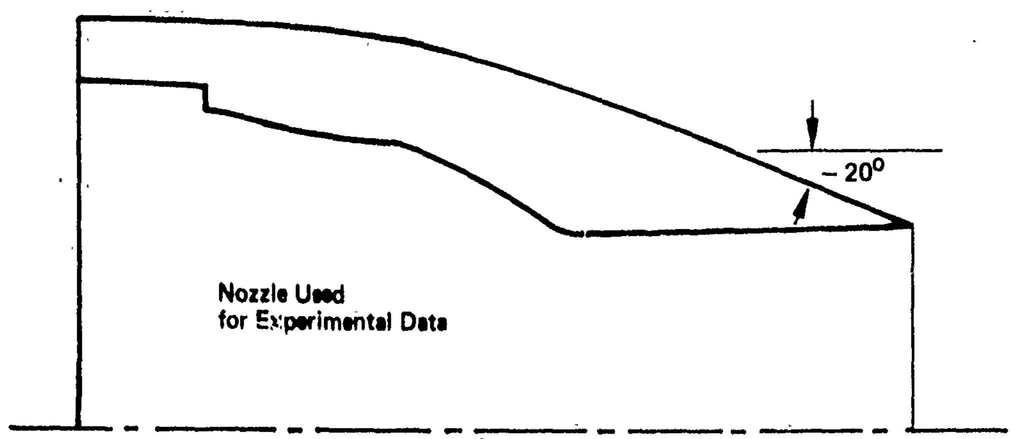


Figure 24: COMPARISON OF PREDICTED AND TEST DATA FOR NOZZLE/AFTERBODY DRAG



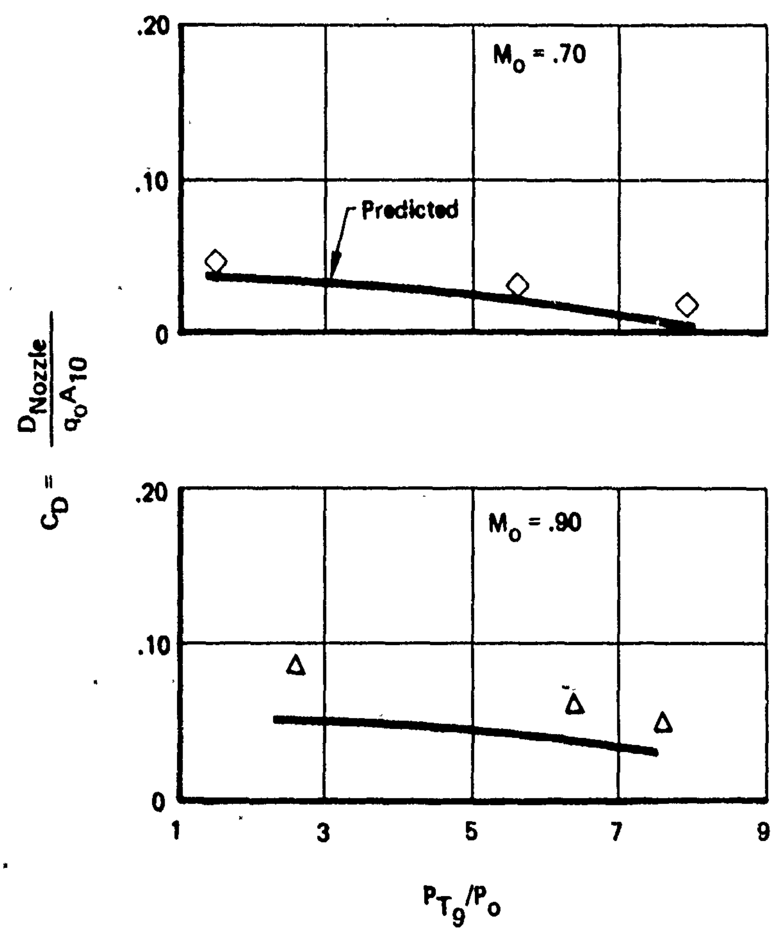


Figure 25: ***COMPARISON OF PREDICTED AND TEST DATA FOR SUBSONIC NOZZLE/AFTERBODY DRAG AS A FUNCTION OF NOZZLE PRESSURE RATIO***

2.4 SUMMARY OF INPUT DATA FOR LIGHTWEIGHT FIGHTER SAMPLE CASE

The input data used for the TEM 333 calculation of the LWF sample case are summarized in the following table:

INLET GEOMETRY	FIGURE 3
SUBSONIC DIFFUSER GEOMETRY	FIGURE 4
NOZZLE/AFTERBODY GEOMETRY	FIGURE 6
M_O vs. M_∞	FIGURE 7
P_{T_2}/P_{T_O} vs. A_O/A_C	FIGURE 8
P_{T_2}/P_{T_O} vs. M_O	FIGURE 9
A_O/A_C vs. M_O	FIGURE 10
$(A_O/A_C)_{\text{BUZZ LIMIT}}$ vs. M_O	FIGURE 11
$(A_O/A_C)_{\text{DIST. LIMIT}}$ vs. M_O	FIGURE 12
$\Delta C_{D_{SPILL}}$ vs. A_{O_I}/A_C	FIGURE 15
$A_{O_{BLC}}/A_C$ vs. A_{O_I}/A_C	FIGURE 16
$C_{D_{BLC}}$ vs. $A_{O_{BLC}}/A_C$	FIGURE 18
$C_{D_{\text{REF. NOZZLE}}}$ vs. M_O	FIGURE 21
ENGINE PERFORMANCE TABULATED DATA	CLASSIFIED (NOT INCLUDED IN THIS REPORT)

SECTION III

F-4J SAMPLE CASE

3.1 CONFIGURATION

3.1.1 Inlet

The general configuration of the F-4J is shown in Figure 2. The inlets are side-mounted, variable geometry, vertical ramp, two-dimensional, with boundary layer bleed through a porous second ramp and a small throat slot. Figure 26 shows the available details of the inlet and subsonic diffuser. These lines were taken from a drawing of a wind tunnel model used during tests reported in Reference 2. The sideplates are cut back completely ahead of the cowl lip. The initial ramp angle is fixed at 10 degrees and the second ramp angle varies from 0 degree relative to the first ramp angle relationships are shown in Figure 27.

The inlet geometry used for the analysis of the F-4J inlet performance characteristics is shown in Figures 28 and 29.

3.1.2 Nozzle/Afterbody

The nomenclature used for the nozzle afterbody drag prediction is shown in Figure 30. Typical nozzle geometries and operating pressure ratios are shown in Figure 31.

The nozzle/afterbody geometric parameters (full scale) used in the prediction method are summarized in the following table:

PARAMETER		VALUE
Max Nozzle Diameter,	D_{MAX}	38.6 in.
Boattail Length,	L	23.4 in.
Nozzle Spacing,	S	53.8 in.

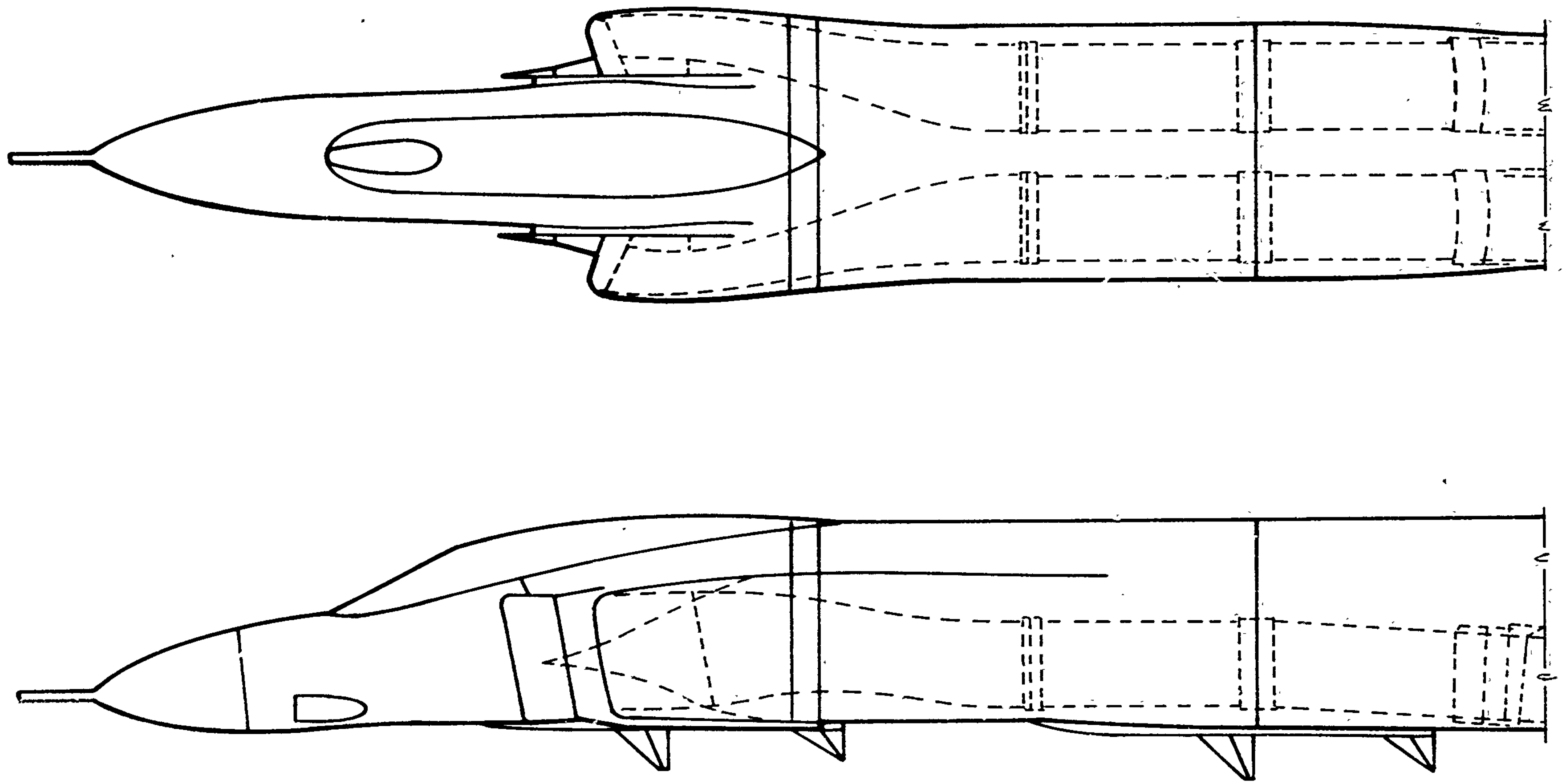


Figure 26: BASIC F-4J FUSELAGE, CANOPY, AND DUCT CONFIGURATION

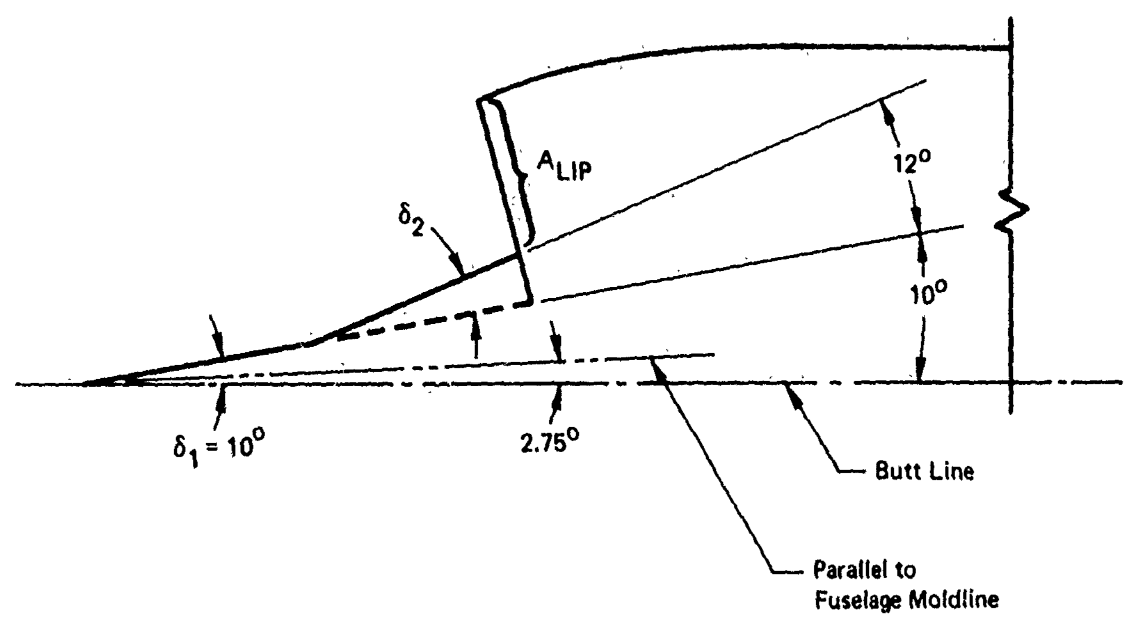
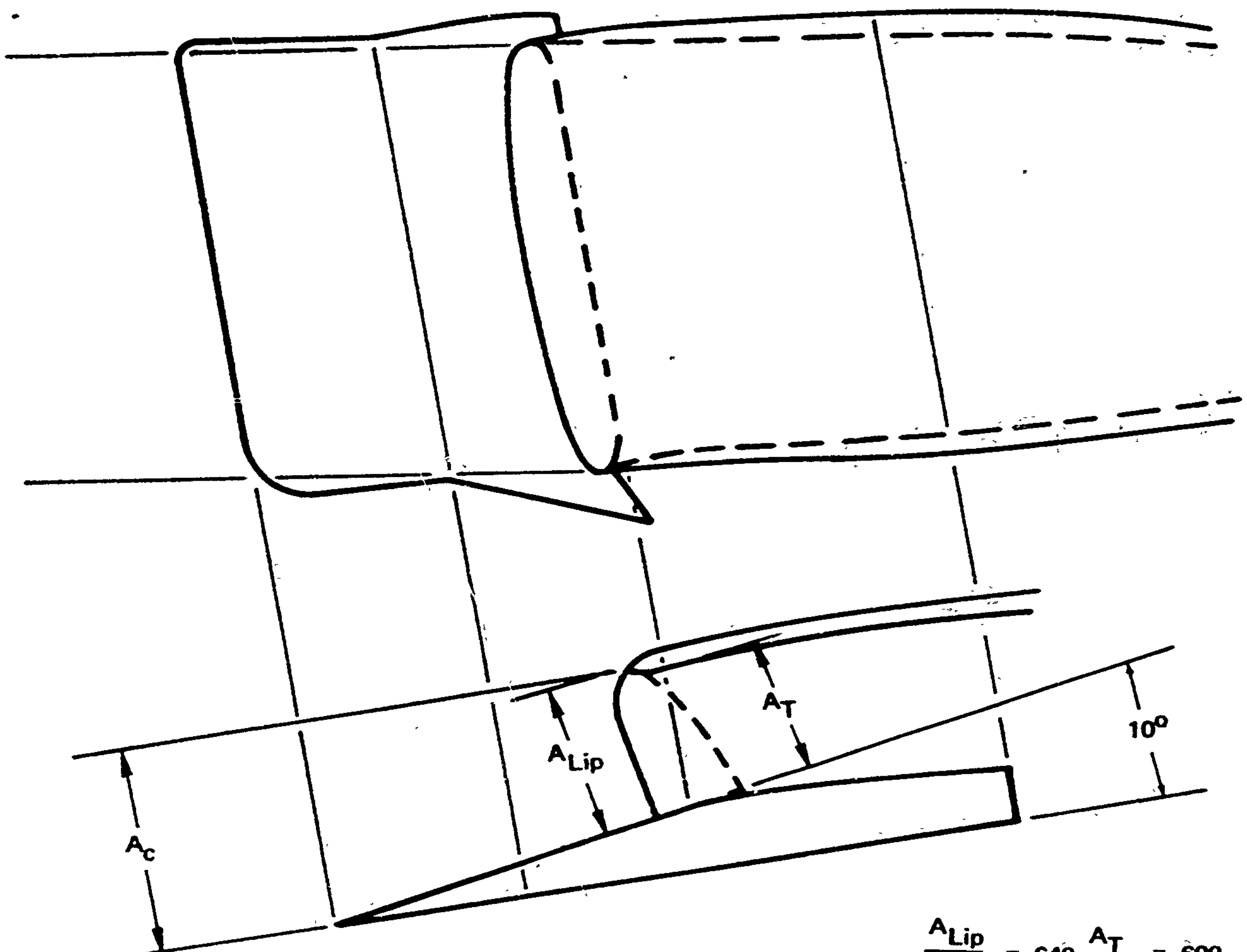


Figure 27: F-4 INLET RAMP ORIENTATION



$\frac{A_{Lip}}{A_c} = .649 \quad \frac{A_T}{A_c} = .609$

Figure 28: *INLET GEOMETRY FOR $M_\infty = 0 - 1.20$*

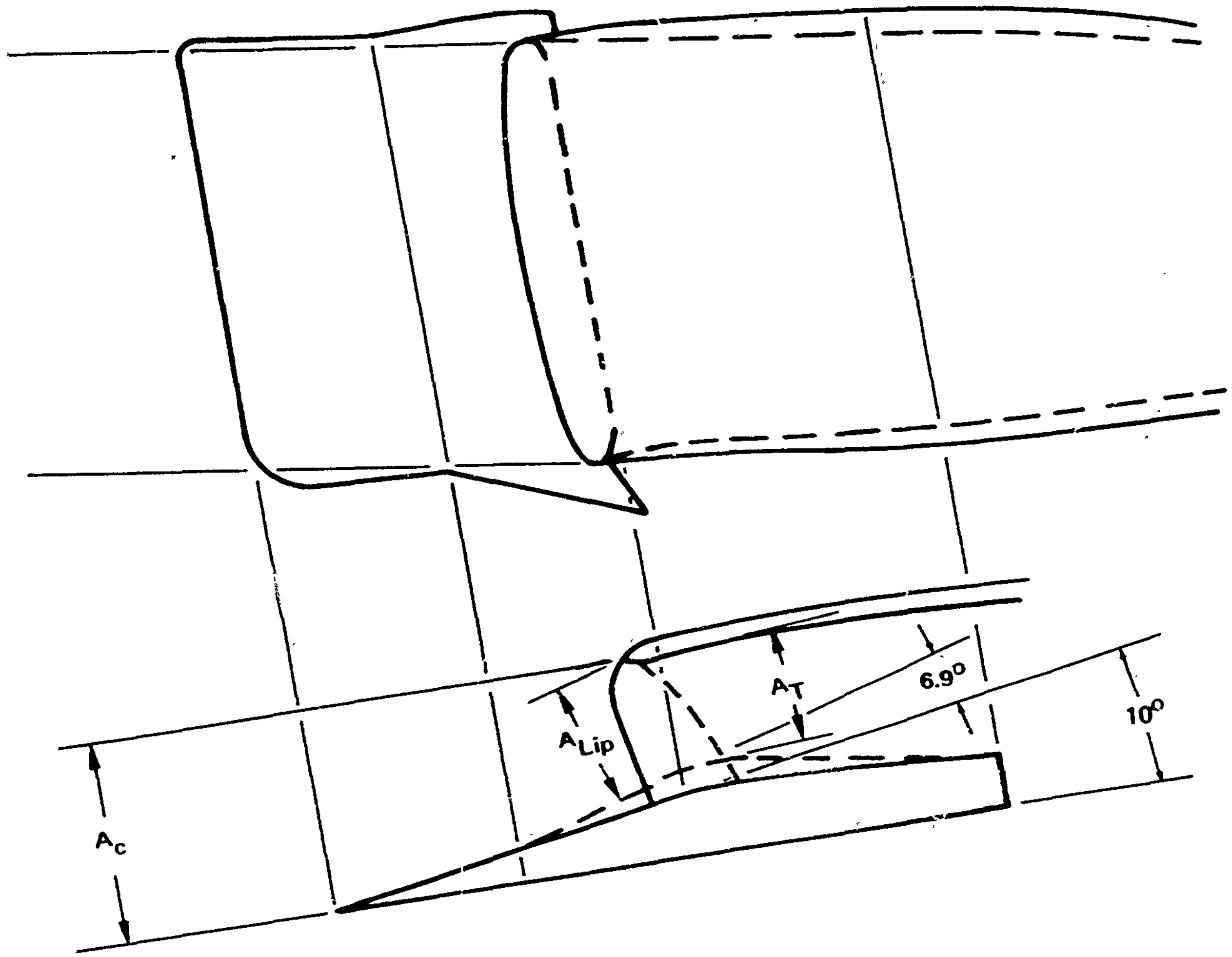


Figure 29: ***INLET GEOMETRY FOR M_∞ = 1.60 – 2.0***

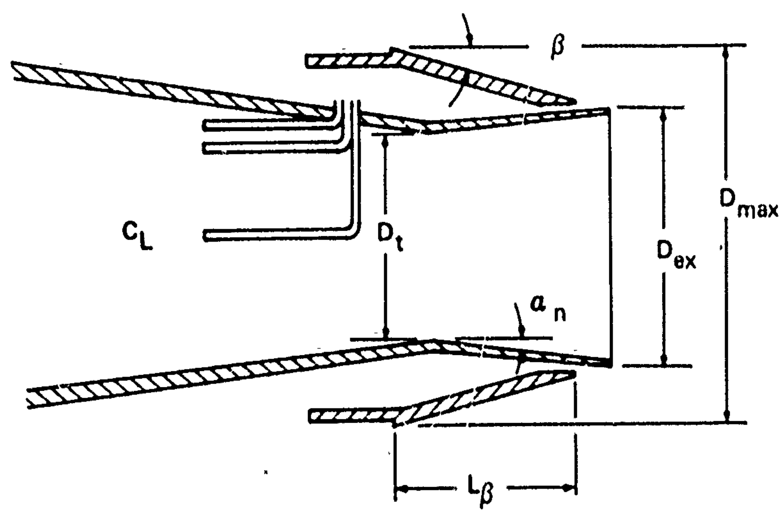


Figure 30: MODEL F-4J/B NOZZLE & SHROUD ARRANGEMENT

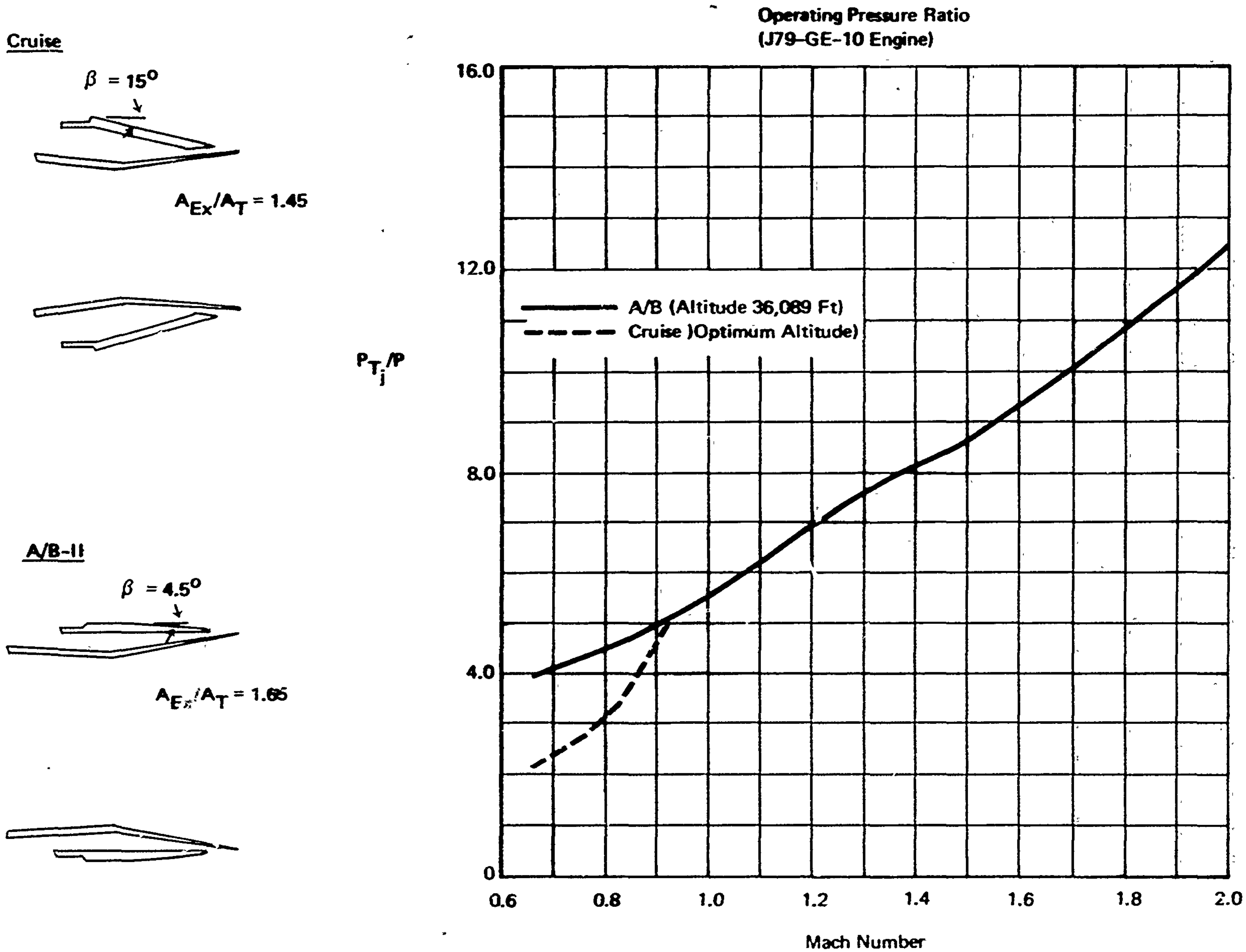


Figure 31: *NOZZLE GEOMETRY AND OPERATING CONDITIONS*

3.2 PREDICTED PERFORMANCE CHARACTERISTICS

3.2.1 Inlet

The same procedure was used to calculate the F-4J inlet performance that was used to calculate the inlet performance of the LWF previously discussed. The basic geometries of the two configurations are quite similar, except for the fact that the F-4J inlet is oriented with the ramp vertical instead of horizontal.

The same K_{ADD} factors were used for both the F-4J and the LWF. These factors are shown in Figure 14. The F-4J inlet geometry was used in the additive drag program (Reference 1) to obtain additive drags. These were then adjusted to the correct baseline mass flow ratio, and multiplied by the K_{ADD} factors to obtain the final spillage drags shown in Figure 39.

The predicted inlet performance characteristics for the F-4J are presented in Figures 32 through 41, in a format that is compatible with the TEM 333 program input.

3.2.2 Nozzle/Afterbody

Just as in the case of the LWF nozzle/afterbody drag calculation, the only input data required (in addition to geometric constants and engine performance tabulated data) is the nozzle/afterbody reference drag. This was determined from the data in Figure 40, 41 and 45, Volume I. The resulting reference drag is presented in Figure 42.

3.3 COMPARISON OF PREDICTED AND TEST DATA

Most of the F-4 experimental data which are available for comparing with predicted data are classified. To include these data in this report, it would be necessary to classify the report, which would limit its distribution.

Since the primary purpose of this report is to provide guidance in the use of the calculation procedure, it was decided not to include classified data, so the report could have the widest possible distribution.

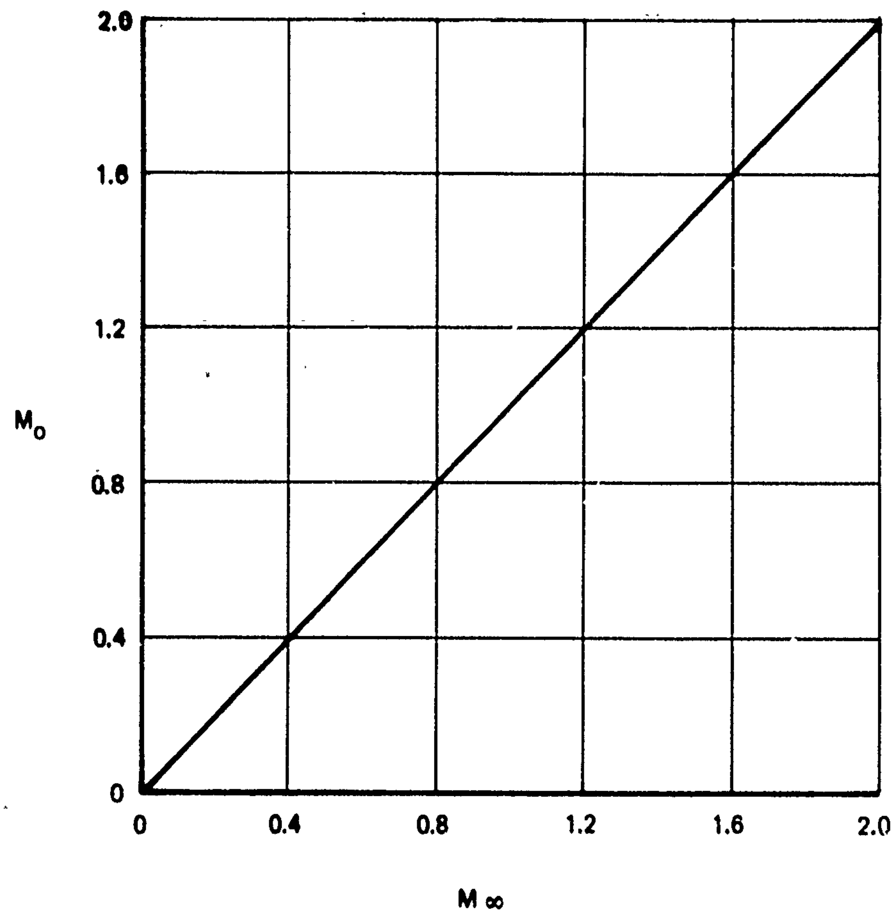


Figure 32: ***LOCAL MACH NUMBER VS FREE-STREAM MACH NUMBER***

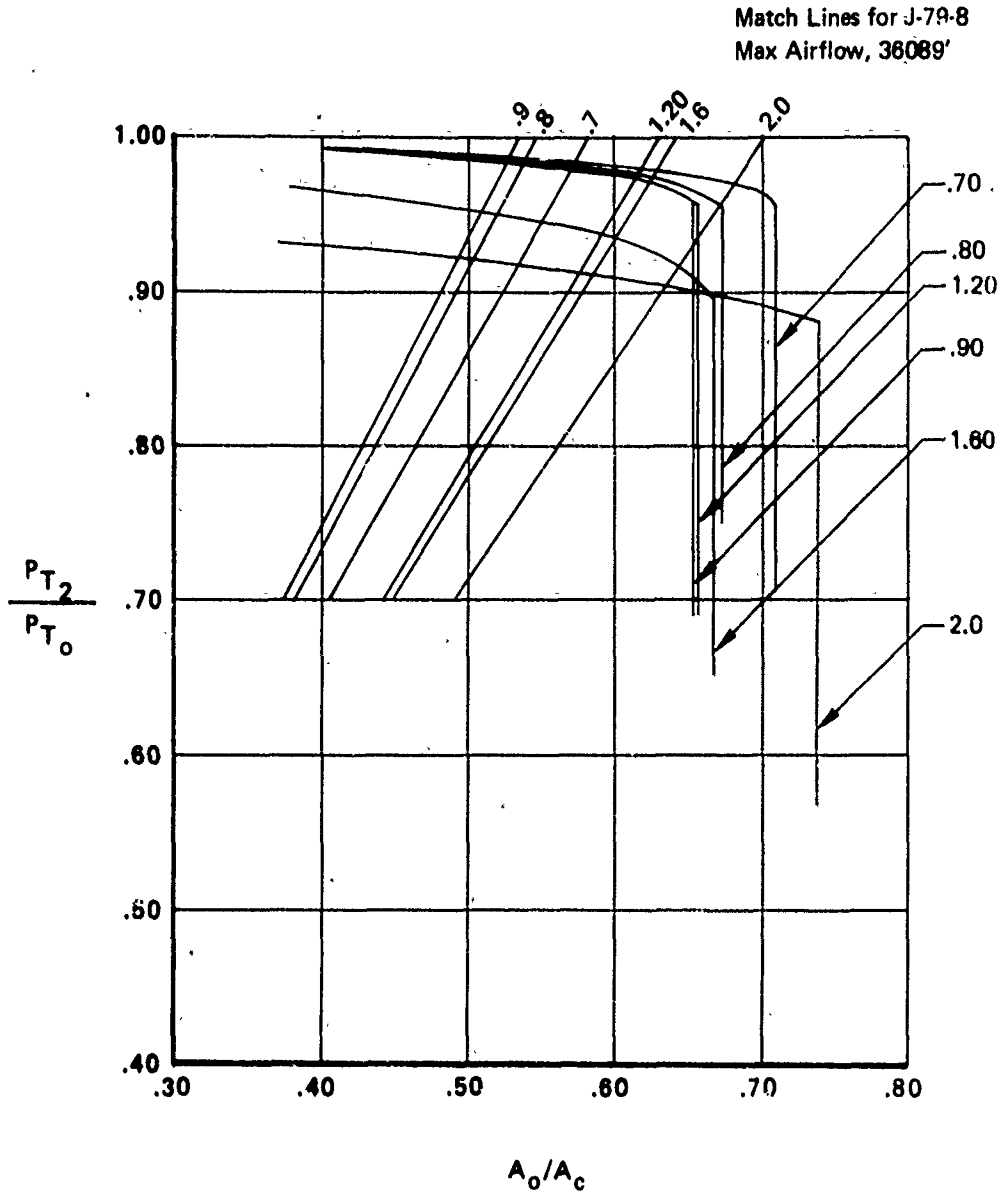


Figure 33: TOTAL PRESSURE RECOVERY VS MASS FLOW RATIO

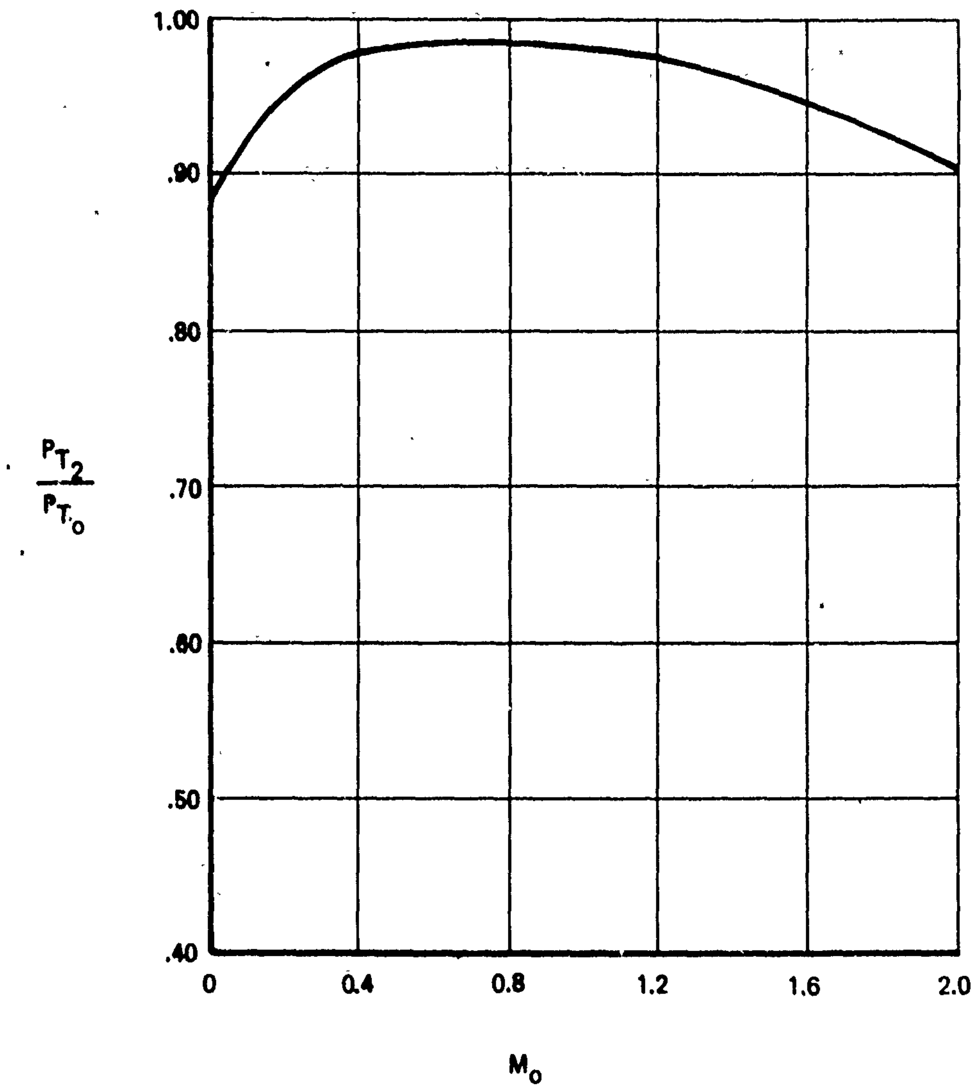


Figure 34: MATCHED INLET RECOVERY

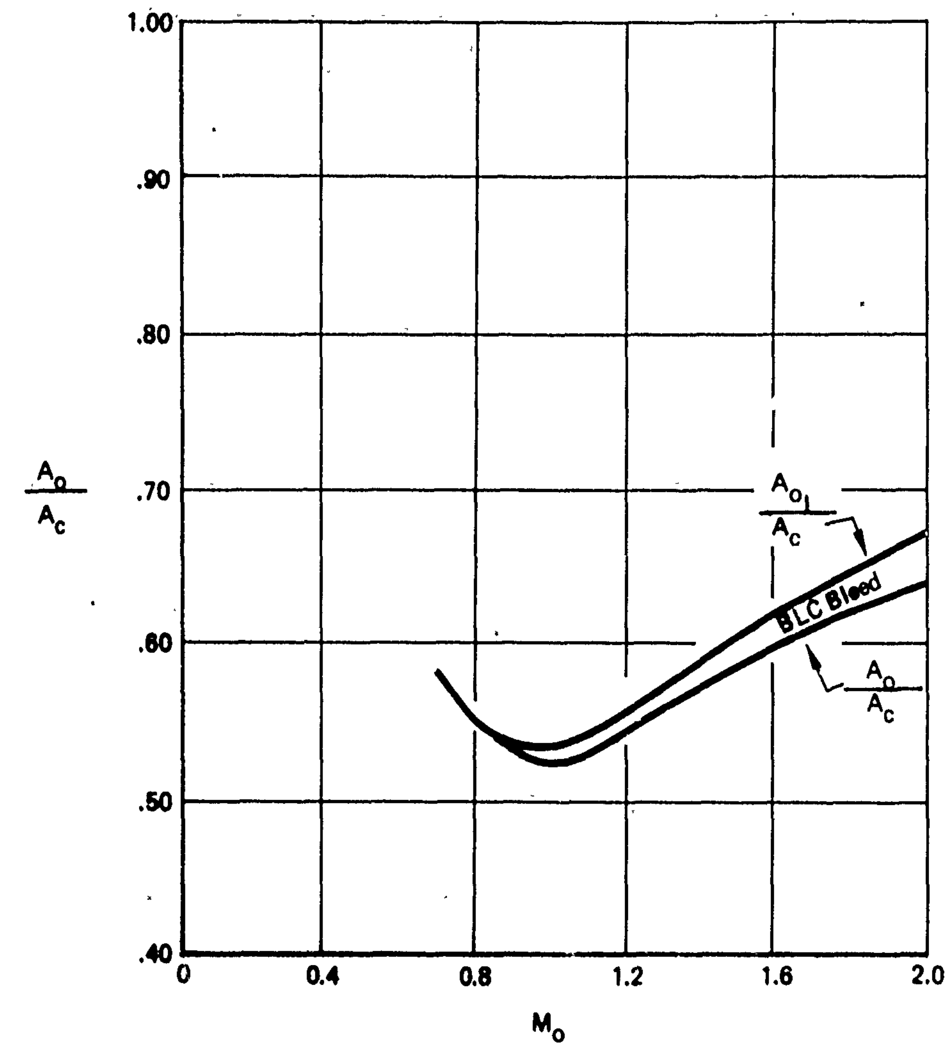


Figure 35: MATCHED INLET MASS FLOW RATIO

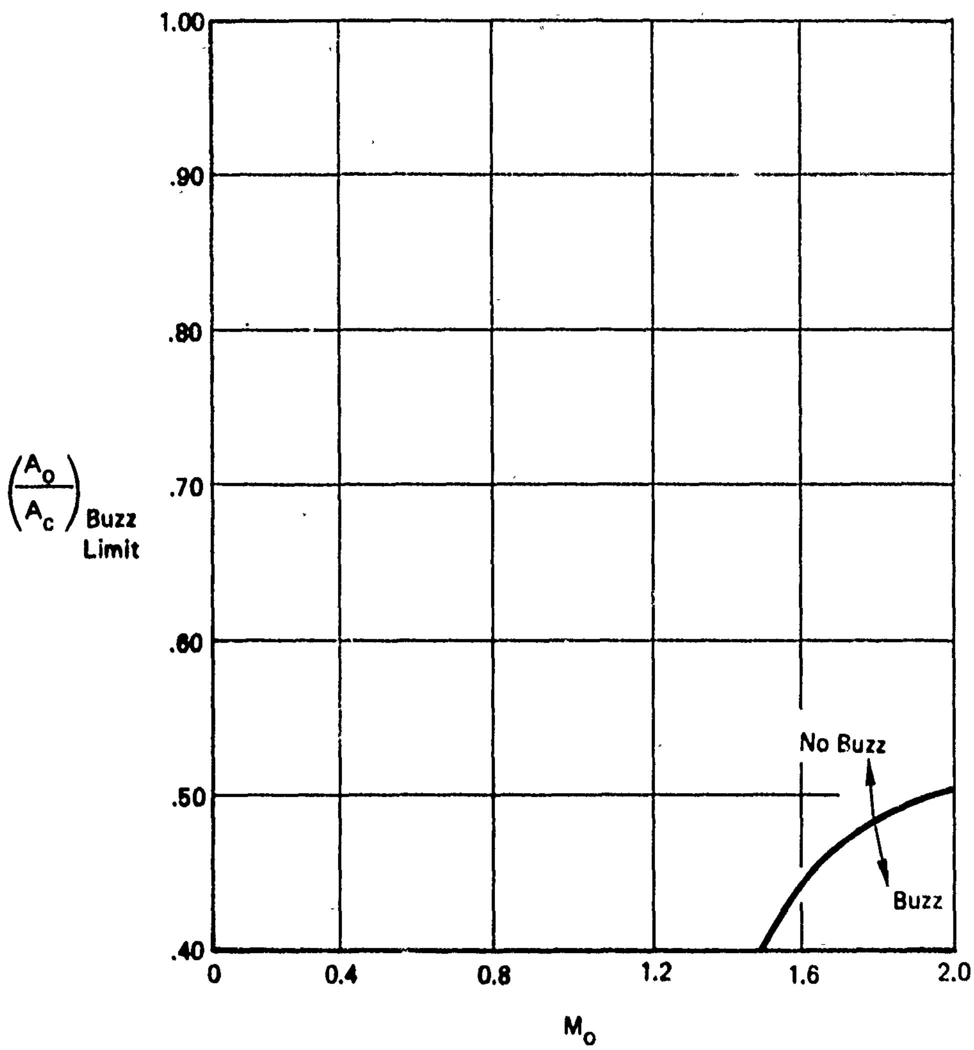


Figure 36: BUZZ LIMIT

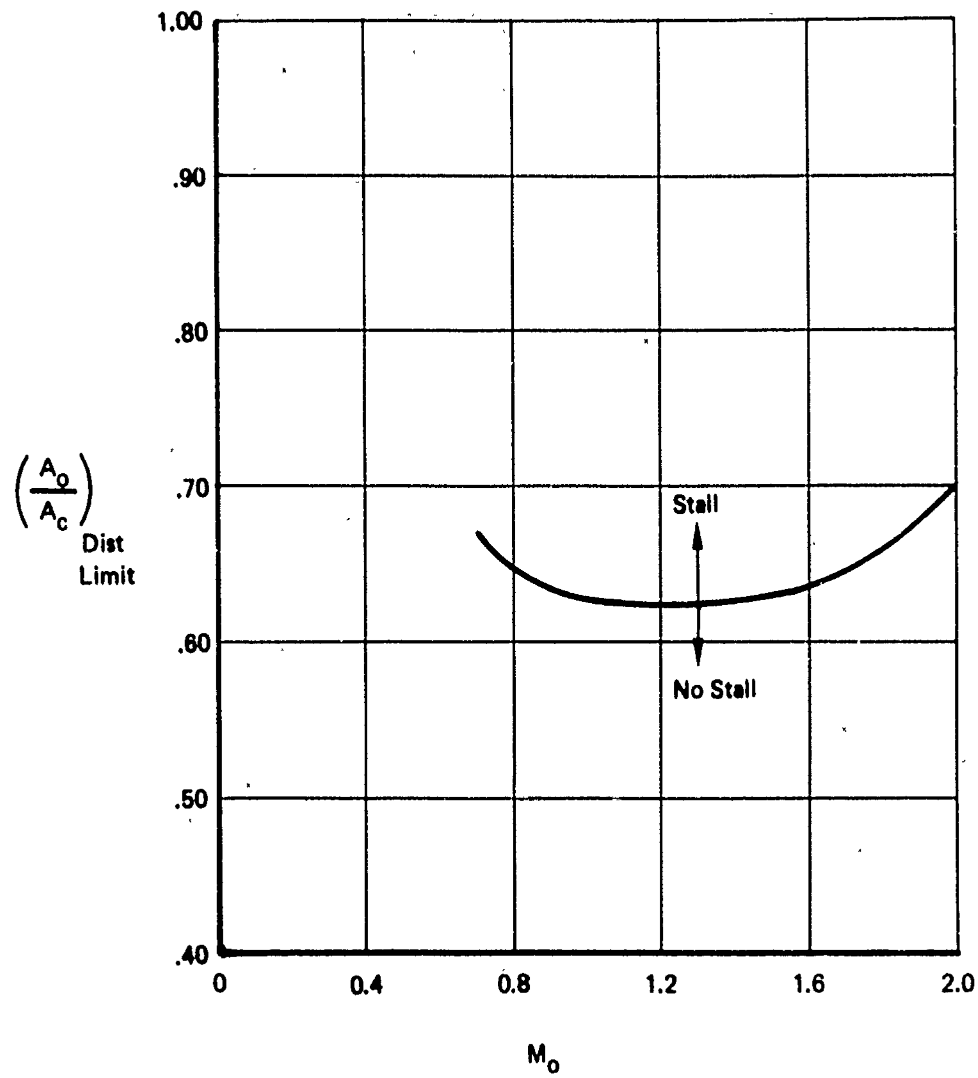


Figure 37: DISTORTION LIMIT

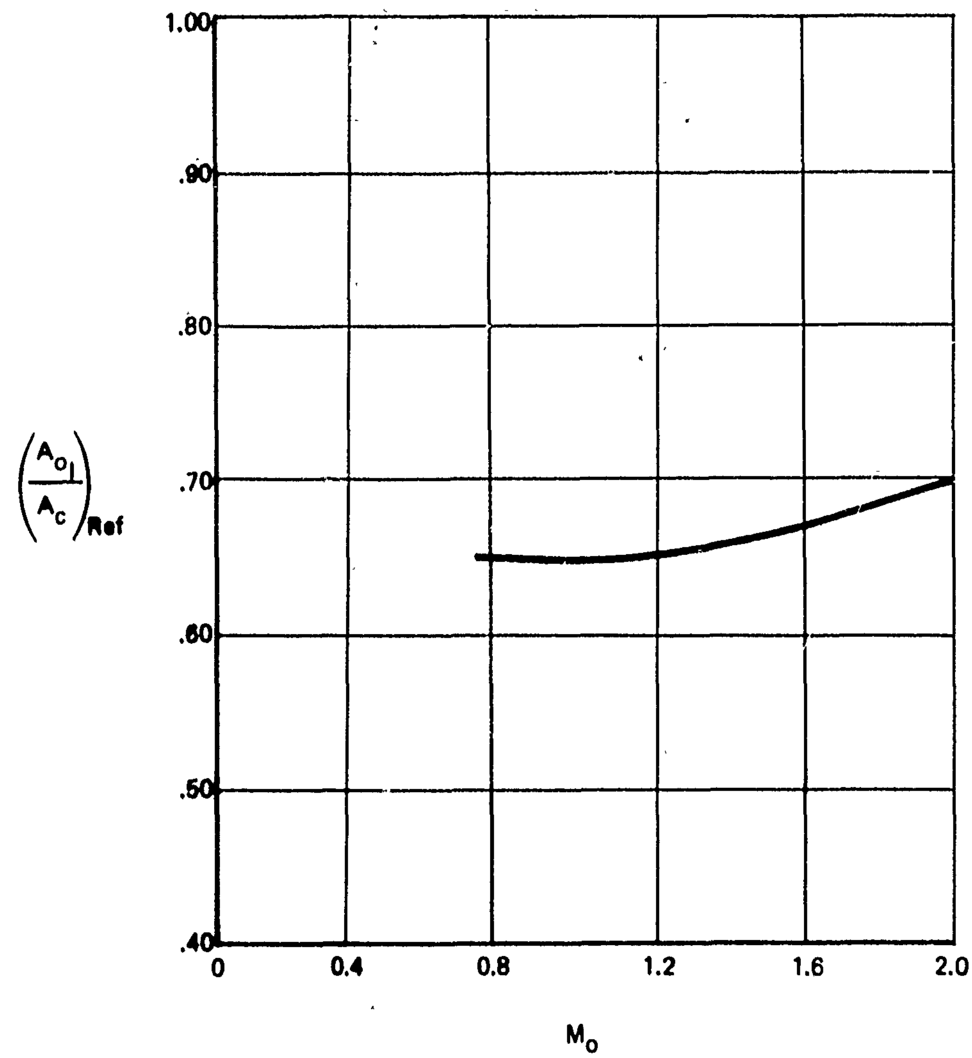


Figure 38: REFERENCE MASS FLOW RATIO

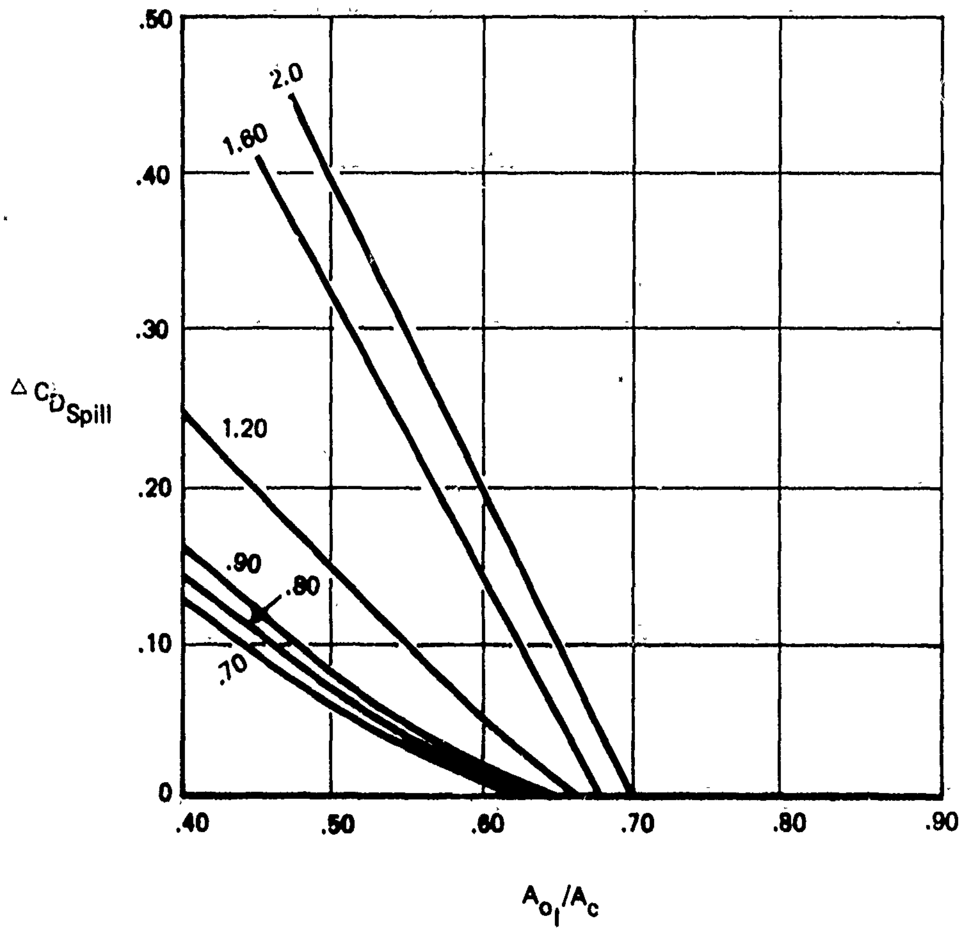


Figure 39: INLET SPILLAGE DRAG

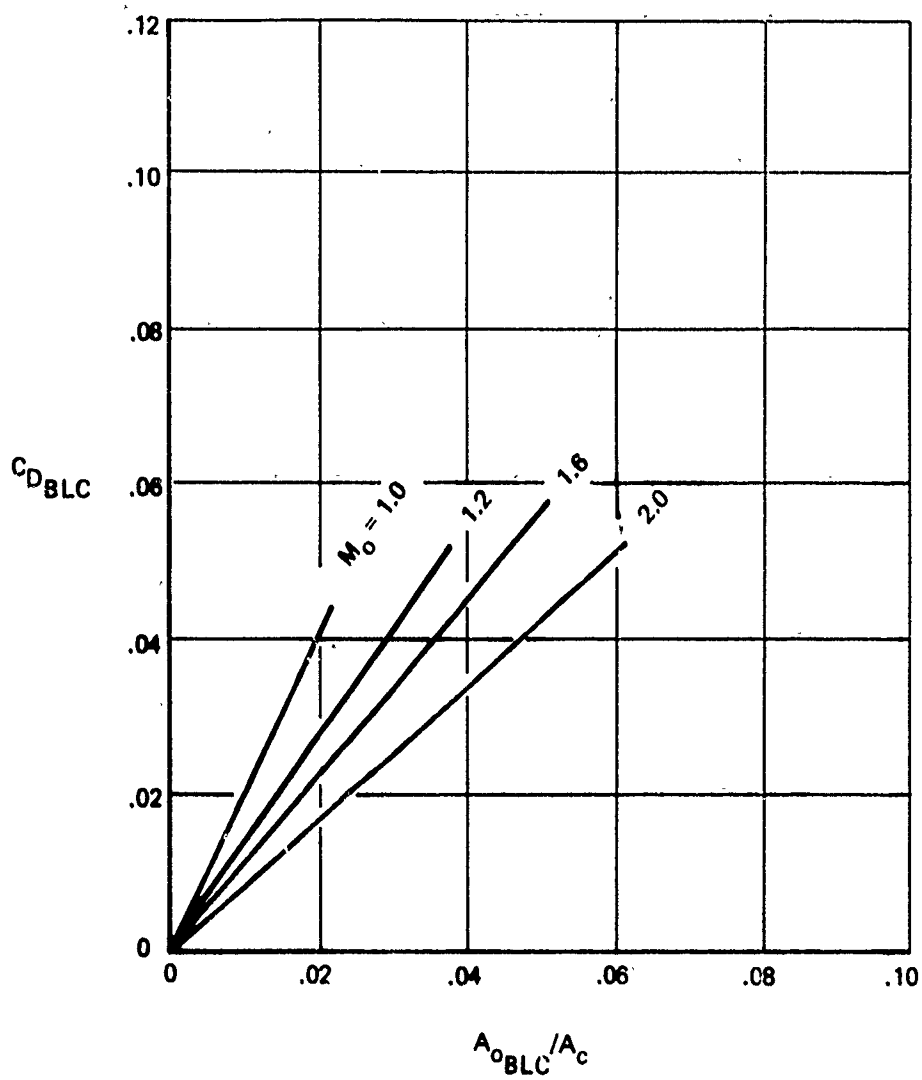


Figure 40: *BOUNDARY LAYER BLEED DRAG*

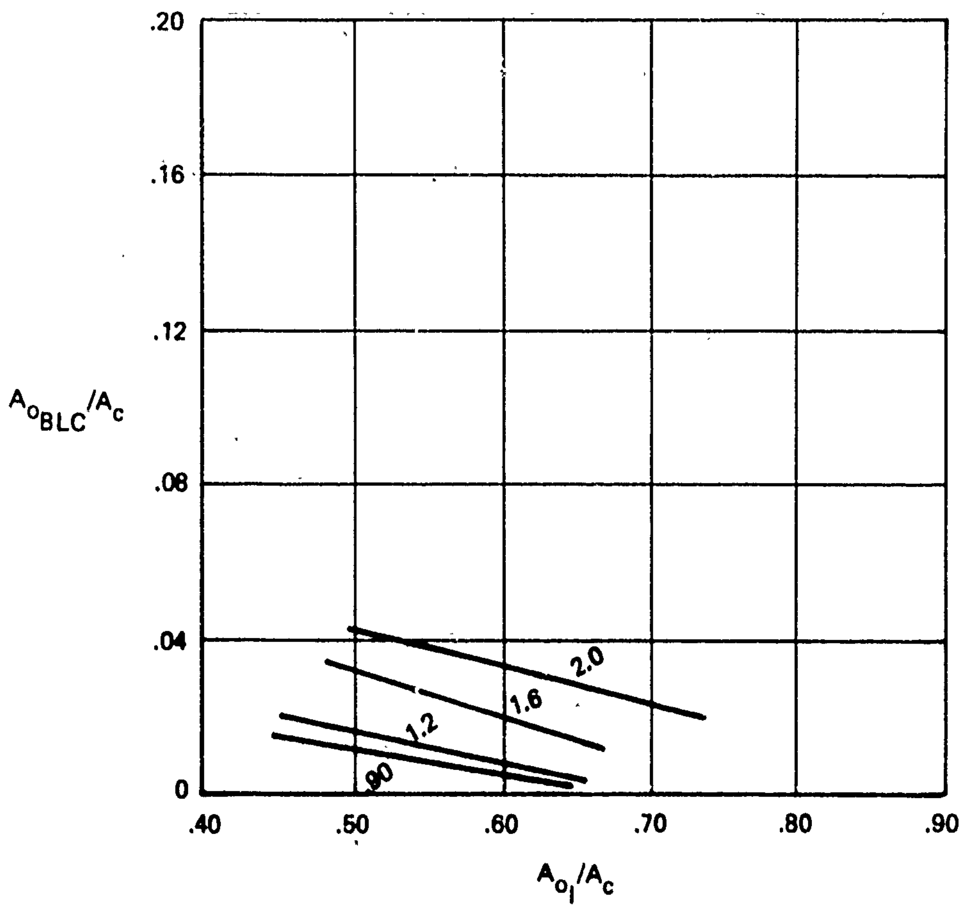


Figure 41: BOUNDARY LAYER BLEED AIRFLOW

$$A_{Ref} = .785\,(D_{Max})^2 = 1{,}170 \text{ In.}^2$$

$$D_{Max} = 38.6 \text{ In.}$$

$$C_{D_{Ref\,Nozzle}} = \frac{D_{Ref}}{q_o\,A_{Max}}$$

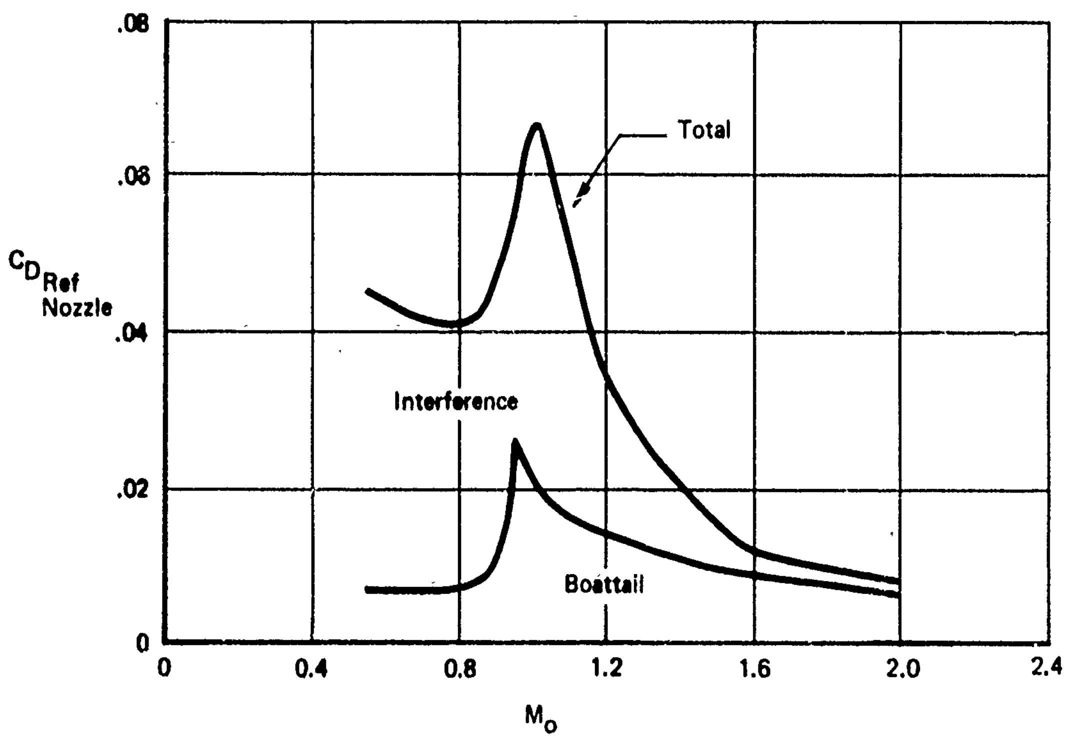


Figure 42: REFERENCE NOZZLE DRAG FOR F-4J

3.4 SUMMARY OF INPUT DATA FOR F-4J

The F-4J data used for input to the TEM 333 program to calculate installed propulsion system performance are summarized in the following table:

INLET GEOMETRY	FIGURE 26, 27, 28, 29
SUBSONIC DIFFUSER GEOMETRY	FIGURE 26
NOZZLE/AFTERBODY GEOMETRY	FIGURE 30, 31
M_O vs. M_∞	FIGURE 32
P_{T_2}/P_{T_O} vs. A_O/A_C	FIGURE 33
P_{T_2}/P_{T_O} vs. M_O	FIGURE 34
A_O/A_C vs. M_O	FIGURE 35
$(A_O/A_C)_{\text{BUZZ LIMIT}}$ vs. M_O	FIGURE 36
$(A_O/A_C)_{\text{DIST. LIMIT}}$ vs. M_O	FIGURE 37
$(A_{O_I}/A_C)_{\text{REF.}}$ vs. M_O	FIGURE 38
$\Delta C_{D_{SPILL}}$ vs. A_{O_I}/A_C	FIGURE 39
$C_{D_{BLC}}$ vs. $A_{O_{BLC}}/A_C$	FIGURE 40
$A_{O_{BLC}}/A_C$ vs. A_{O_I}/A_C	FIGURE 41
$C_{D_{\text{REF. NOZZLE}}}$ vs. M_O	FIGURE 42
TABULATED ENGINE PERFORMANCE DATA	J79-GE-8

3.5 SAMPLE INPUT AND OUTPUT DATA FOR F-4J

This section contains sample input and output data taken directly from the computer program printout for the F-4J installed performance calculation. It is included to illustrate the format of the input and output data and to present typical results of a calculation.

OUTPUT

Standard printed output includes:

1. A "card image" listing of all input cards.

2. Labeled listing of all input fields as stored in the computer. The expanded table 2A is output as is the internally generated table of $Mach_9$ as a function of A_8/A_9 for γ_1.

3. Output matrices including the input and output data for each of one to ten cases. A new matrix is printed whenever Mach number changes, altitude changes, or ten points have been computed at the current Mach and altitude. For each case the following are printed.

CASE	Sequential case number	
ALT	Pressure altitude - input	ft.
PS	Power setting - input	
FNA	Installed net thrust	lb.
WFT RF	Installed fuel flow corrected for recovery	
SFCA	(WFT RF)/(FNA)	
FNRF	Input thrust corrected for recovery	lb.
FRAM	Ram drag	lb.
RF	Recovery factor	
MILRF	Mil-Spec recovery factor	
DINLET	Inlet drag	lb.
CDSPL	Coefficient of spillage drag	

CDBLD	Coefficient of bleed drag	
CDBYP	Coefficient of bypass drag	
CDINL	Coefficient of inlet drag	
DNOZ	Afterbody drag	lb.
CDBT	Coefficient of boattail drag	
CDBASE	Coefficient of base drag	
DCINT	Coefficient of nozzle interference drag	
DNOZ REF	Reference afterbody drag	lb.
P8/PO	Nozzle pressure ratio - input	
A9	Nozzle exit area - input	sq. in.
A8	Nozzle throat area - input	sq. in.
CFG	Nozzle gross thrust coefficient	
BETA	Boattail angle	degrees
FN INPUT	Net thrust - input	lb.
WF INPUT	Fuel flow - input	lb/hr.
SFC INPUT	(WF INPUT)/(FN INPUT)	
W INPUT	Corrected airflow - input	lb/sec.
W ABS	Absolute airflow	lb/sec.
FN/DELTA	FNA/δamb	lb.
WF COR	WFT RF/(θamb δamb)	lb/hr.
SFC COR	(WF COR)/(FN/DELTA	
TAMB	Ambient temperature	^{o}R
PAMB	Ambient pressure	
TTO	Total temperature of free-stream	^{o}R
Q	Dynamic pressure	lb/sq. ft.

AOE/AC	Engine mass flow ratio
AOI/AC	Inlet capture mass flow ratio
AO/AC	Inlet mass flow ratio
STATUS	If equal to -99.999 a diagnostic message was written for this point.

4. Diagnostic messages. The diagnostic messages are all self-explanatory.

5. MARK II Output.

   If the code on card 5.1, field 1, is 1.0 or 2.0 a MARK II engine performance deck is written on TAPE 7. The format is 80 character BCD, "card image." The MARK II deck can then be copied to PUNCH or linked to a following program.

   The MARK II format is as follows:

   1. Title (card image of input card 1.0)

   2. Mach-alt (card image of input card 5.2)

DATA INPUT CARD IMAGES

DEC 06, 1972

CARD	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**

CARD											
1		J79-8 F4 CONFIGURATION WS/WB=.08									
2											
3											
4											
5	0.	.4	.75	.85	.95	1.0	1.2	1.5	1.8	2.0	NOZ REF
6	.044	.044	.041	.042	.05	.066	.035	.0152	.011	.009	J79-8
7	6.82	2.01									
8	0.	3.									TAB 1
9	0.	3.									
10	.5	.7	.8	.9	1.2	1.6	2.0				TAB 2
11	.3	.5	.6	.7	.8	.825	.85				.6
12	.995	.99	.985	.980	.972	.965	.95				
13	.3	.5	.6	.65	.675	.70	.72				.7
14	.995	.99	.983	.975	.970	.965	.955				
15	.3	.5	.6	.625	.650	.675					.8
16	.995	.987	.983	.975	.968	.958					
17	.3	.5	.6	.625	.650	.655					.9
18	.995	.987	.978	.970	.960	.958					
19	.3	.5	.6	.625	.650	.66					1.2
20	.995	.967	.973	.970	.960	.958					
21	.30	.5	.6	.625	.65	.670					1.6
22	.974	.952	.935	.925	.912	.895					
23	.3	.5	.6	.7	.725	.74					2.0
24	.935	.92	.91	.891	.885	.881					
25	0.	.2	.4	.6	1.0	1.2	1.6	2.0			TAB 2B
26	.38	.95	.977	.98	.98	.97	.945	.905			
27	0.	.7	.8	.9	1.0	1.2	1.6	2.0			TAB 2C
28	1.	.575	.545	.535	.535	.55	.62	.665			
29	0.	1.5	1.6	1.8	2.0						TAB 2D
30	0.	0.	.45	.484	.5						
31	0.	.7	.8	1.	1.4	1.6	2.0				TAB 2E
32	1.	.67	.65	.627	.625	.635	.7				
33	.5	.7	.8	.9	1.2	1.6	2.0				TAB 3
34	.4	.5	.6	.65	.665	.68	.70				
35	.114	.052	.01	0.	0.	0.	0.				.6
36	.128	.06	.011	0.	0.	0.	0.				.7
37	.145	.07	.015	0.	0.	0.	0.				.8
38	.153	.08	.022	0.	0.	0.	0.				.9
39	.25	.144	.052	.012	0.	0.	0.				1.2
40	.5	.32	.14	.05	.025	0.	0.				1.6
41	.5	.4	.20	.10	.07	.048	0.				2.0
42	1.0	1.2	1.6	2.0							TAB 4
43	0.	.02	.04	.06							
44	0.	.04	.08	.12							1.
45	0.	.0275	.055	.082							1.2
46	0.	.0225	.045	.0675							1.6
47	0.	.017	.0345	.051							2.0
48	0.										TAB 5
49	0.										
50	0.										

DATA INPUT CARD IMAGES

CARD	1	2		3		4		5		6	7	8	DEC 06, 1972
	1234567890	1234567890		1234567890		1234567890		1234567890		1234567890	1234567890	1234567890	
51	1.	1.2	1.6	2.0							TAB 6A		
52	.4	.685	.71	.775	.95								
53	.018	0.	0.	0.	0.								
54	.024	.002	0.	0.	0.								
55	.044	.01	.007	0.	0.								
56	.052	.026	.023	.017	0.								
57	0.										TAB 6B		
58	0.												
59	0.										TAB 7		
60	0.												
61	0.												
62	0.	1.	38.6	0.	0.	23.4	53.8	0.	0.	10.			
63	1.3												
64	0.	.5	.3	.9	1.	1.1	1.2	1.6	2.0				
65	1.	.972	.934	.91	.865	.8	.79	.74	.69				
66	0.0	.55	.75	.85	.95	1.0	1.22	1.53	1.8	2.4	TABLE 5		
67	1.0	1.42	1.53	1.68	2.2	2.34	2.40	2.70	3.2				
68	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0				
69	.005	.012	.009	.004	.0025	.0025	.0025	.0025	.0025				
70	.005	.013	.014	.008	.005	.005	.005	.005	.005				
71	.005	.014	.015	.018	.008	.008	.008	.008	.008				
72	.005	.018	.020	.024	.033	.032	.030	.025	.025				
73	.005	.025	.029	.035	.059	.0625	.055	.033	.029				
74	.019	.019	.019	.019	.019	.019	.019	.019	.019				
75	.0075	.0075	.0075	.0075	.0075	.0075	.0075	.0075	.0075				
76	.005	.005	.005	.005	.005	.005	.005	.005	.005				
77	.005	.005	.005	.005	.005	.005	.005	.005	.005				
78	0.	2.0	0.	2.	2.								
79	0.												
80		0.	1.	17000.	33221.	159.							
81		5000.	1.	14400.	28360.	143.							
82	.2												
83		0.	1.	16200.	33920.	173.							
84		5000.	1.	13800.	29303.	146.							
85		15000.	1.	9800.	20355.	102.							
86	.4												
87		0.	1.	16500.	35935.	135.							
88		5000.	1.	14200.	30970.	157.							
89		15000.	1.	10100.	21899.	110.							
90		25000.	1.	6963.	15008.	75.							
91		35000.	1.	4630.	10153.	49.							
92	.6												
93		0.	1.	17500.	39264.	203.							
94		5000.	1.	15300.	34160.	175.							
95		15000.	1.	11100.	24668.	124.							
96		25000.	1.	7650.	16840.	34.							
97		35000.	1.	5090.	11311.	55.							
98		45000.	1.	3030.	7345.	34.							
99		55000.	1.	1760.	4445.	21.							
100	.3												

DATA INPUT CARD IMAGES

CARD 1 2 3 4 5 6 7 8

12345678901234567890123456789012345678901234567890123456789012345678901234567890

DEC 06, 1972

CARD						
101		0.	1.	14300.	44181.	231.
102		5000.	1.	16900.	38240.	198.
103		15000.	1.	12700.	28340.	144.
104		25000.	1.	8860.	19693.	98.
105		35000.	1.	5930.	13114.	64.
106		45000.	1.	3560.	8555.	40.
107		55000.	1.	2050.	5202.	24.
108	1.0					
109		0.	1.	21200.	47605.	272.
110		5000.	1.	19600.	44716.	235.
111		15000.	1.	14900.	32879.	169.
112		25000.	1.	10830.	23611.	118.
113		35000.	1.	7280.	15783.	73.
114		45000.	1.	4400.	10198.	48.
115		55000.	1.	2540.	6300.	29.
116		65000.	1.	1460.	3791.	17.
117	1.2					
118		5000.	1.	21200.	47215.	270.
119		15000.	1.	17700.	38783.	232.
120		25000.	1.	13200.	27655.	142.
121		45000.	1.	5580.	12403.	59.
122		55000.	1.	3260.	7772.	35.
123		65000.	1.	1860.	4693.	22.
124	1.4					
125		15000.	1.	20300.	44393.	235.
126		25000.	1.	15800.	33212.	172.
127		35000.	1.	11300.	23232.	117.
128		45000.	1.	6990.	14852.	73.
129		55000.	1.	4150.	9575.	44.
130		65000.	1.	2370.	5619.	27.
131	1.6					
132		25000.	1.	18230.	38298.	232.
133		35000.	1.	13600.	27843.	143.
134		45000.	1.	8450.	17650.	88.
135		55000.	1.	5050.	11276.	54.
136		65000.	1.	2930.	7129.	33.
137	1.8					
138		25000.	1.	19300.	41367.	223.
139		35000.	1.	15630.	32396.	170.
140		45000.	1.	9890.	20682.	106.
141		55000.	1.	5990.	13139.	65.
142		65000.	1.	3510.	8522.	40.
143	2.0					
144		35000.	1.	16700.	34993.	138.
145		45000.	1.	10700.	22541.	118.
146		55000.	1.	6510.	14284.	72.
147		65000.	1.	3970.	9224.	44.

TEM-333 ENGINE PERFORMANCE PROGRAM

J79-8 F4 CONFIGURATION WS/W8=.08

W8 TABLE

-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000-0
-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000-0
-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000-0

REFERENCE NOZZLE DRAG TABLE

0.00000	.40000	.75000	.85000	.95000	1.00000	1.20000	1.50000	1.80000	2.00000-0NOZ REF
.04400	.04400	.04100	.04200	.06000	.06600	.03500	.01520	.01100	.00900-0 J79-8

INLET INPUT DECK	INPUT AC	MACHS	MACH DES	WC ENG	WC SEC
	6.820	2.010	-0.000	-0.0	-0.0

TABLE NUMBER 1

0.00000	3.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000-0TAB 1
0.00000	3.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000-0

TABLE NUMBER 2A

.60000	.70000	.80000	.90000	1.20000	1.60000	2.00000	-0.00000	-0.00000	-0.00000-0TAB 2
.30000	.50000	.60000	.70000	.80000	.82500	.85000	-0.00000	-0.00000	-0.00000-0.6
.99500	.99000	.98500	.98000	.97200	.96900	.95000	-0.00000	-0.00000	-0.00000-0
.30000	.50000	.60000	.65000	.67500	.70000	.72000	-0.00000	-0.00000	-0.00000-0.7
.97500	.99000	.98000	.97500	.97000	.96500	.95500	-0.00000	-0.00000	-0.00000-0
.30000	.50000	.50000	.52500	.65000	.67500	-0.00000	-0.00000	-0.00000	-0.00000-0.8
.99500	.98700	.98000	.97500	.96800	.95800	-0.00000	-0.00000	-0.00000	-0.00000-0
.30000	.50000	.60000	.62500	.65000	.65500	-0.00000	-0.00000	-0.00000	-0.00000-0.9
.99500	.93700	.97800	.97000	.96000	.95600	-0.00000	-0.00000	-0.00000	-0.00000-0
.30000	.50000	.60000	.62500	.65000	.66000	-0.00000	-0.00000	-0.00000	-0.00000-01.2
.99500	.98700	.97800	.97000	.96000	.9[illegible]500	-0.00000	-0.00000	-0.00000	-0.00000-0
.30000	.50000	.60000	.62500	.65000	.67000	-0.00000	-0.00000	-0.00000	-0.00000-01.6
.97400	.95200	.93500	.92500	.91200	.89500	-0.00000	-0.00000	-0.00000	-0.00000-0
.30000	.50000	.60000	.70000	.72500	.74000	-0.00000	-0.00000	-0.00000	-0.00000-02.0
.93500	.92000	.91000	.89100	.88500	.88100	-0.00000	-0.00000	-0.00000	-0.00000-0

TABLE 2A AS EXPANDED TO +1 POINTS WITH INTERMEDIATE MACH CURVES INTERPOLATED AS DIAGNOSTIC AID

.60											
	.3000	.3275	.3550	.3825	.4100	.4375	.4650	.4925	.5200	.5475	.5758
		.5842	.5933	.6025	.6117	.6208	.6300	.6392	.6483	.6575	.6667
		.6758	.6850	.6942	.7033	.7125	.7217	.7308	.7400	.7492	.7583
		.7675	.7767	.7858	.7950	.8042	.8133	.8225	.8317	.8408	.8500
	.9950	.9943	.9936	.9929	.9922	.9916	.9909	.9902	.9890	.9876	.9862
		.9858	.9853	.9849	.9844	.9840	.9835	.9830	.9826	.9821	.9817
		.9812	.9807	.9803	.9797	.9790	.9783	.9775	.9768	.9761	.9753
		.9746	.9739	.9731	.9724	.9715	.9704	.9693	.9639	.9570	.9500
.65											
	.3300	.3242	.3485	.3727	.3970	.4212	.4455	.4697	.4940	.5182	.5425
		.5516	.5587	.5668	.5748	.5829	.5910	.5991	.6072	.6153	.6233
		.6314	.6395	.6476	.6557	.6638	.6718	.6799	.6880	.6961	.7042
		.7123	.7203	.7284	.7365	.7446	.7527	.7608	.7688	.7769	.7850
	.9950	.9944	.9938	.9932	.9926	.9920	.9914	.9908	.9899	.9889	.9876
		.9870	.9865	.9859	.9853	.9847	.9841	.9836	.9830	.9824	.9818
		.9813	.9807	.9801	.9795	.9787	.9780	.9773	.9765	.9759	.9752
		.9741	.9730	.9720	.9709	.9697	.9685	.9672	.9630	.9577	.9525
.70											
	.3300	.3210	.3420	.3630	.3840	.4050	.4260	.4470	.4680	.4890	.5100
		.5170	.5240	.5310	.5380	.5450	.5520	.5590	.5660	.5730	.5800
		.5870	.5940	.6010	.6080	.6150	.6220	.6290	.6360	.6430	.6500
		.6570	.6640	.6710	.6780	.6850	.6920	.6990	.7060	.7130	.7200
	.9950	.9945	.9939	.9934	.9929	.9924	.9918	.9913	.9908	.9903	.9890
		.9883	.9876	.9869	.9862	.9855	.9848	.9841	.9834	.9827	.9820
		.9813	.9806	.9799	.9792	.9785	.9778	.9771	.9764	.9757	.9750
		.9736	.9722	.9708	.9694	.9680	.9666	.9652	.9620	.9585	.9550
.75											

	.3000	.3199	.3397	.3596	.3795	.3994	.4192	.4391	.4590	.4789	.4987
		.5054	.5120	.5186	.5253	.5319	.5385	.5451	.5518	.5584	.5650
		.5716	.5783	.5849	.5915	.5981	.6048	.6114	.6180	.6246	.6313
		.6379	.6445	.6511	.6578	.6644	.6710	.6776	.6843	.6909	.6975
	.9950	.9944	.9937	.9931	.9924	.9918	.9912	.9905	.9899	.9893	.9882
		.9878	.9873	.9867	.9862	.9856	.9850	.9845	.9839	.9833	.9827
		.9822	.9816	.9810	.9805	.9799	.9793	.9788	.9782	.9772	.9762
		.9749	.9736	.9720	.9704	.9689	.9673	.9653	.9625	.9595	.9565
.80											
	.3000	.3187	.3375	.3562	.3750	.3937	.4125	.4312	.4500	.4687	.4875
		.4938	.5000	.5063	.5125	.5188	.5250	.5313	.5375	.5438	.5500
		.5563	.5625	.5688	.5750	.5813	.5875	.5938	.6000	.6063	.6125
		.6188	.6250	.6313	.6375	.6438	.6500	.6563	.6625	.6688	.6750
	.9950	.9942	.9935	.9927	.9920	.9912	.9905	.9897	.9890	.9882	.9875
		.9872	.9870	.9866	.9861	.9857	.9852	.9848	.9844	.9839	.9835
		.9831	.9826	.9822	.9817	.9813	.9809	.9804	.9800	.9787	.9775
		.9752	.9750	.9732	.9715	.9697	.9680	.9655	.9630	.9605	.9580
.85											
	.3000	.3182	.3365	.3547	.3730	.3912	.4095	.4277	.4460	.4642	.4825
		.4886	.4947	.5008	.5069	.5129	.5190	.5251	.5312	.5373	.5433
		.5494	.5555	.5616	.5677	.5738	.5798	.5859	.5920	.5981	.6042
		.6103	.6163	.6224	.6285	.6346	.6407	.6468	.6528	.6589	.6650
	.9350	.9943	.9935	.9923	.9921	.9913	.9906	.9899	.9892	.9884	.9877
		.9875	.9872	.9863	.9865	.9860	.9855	.9851	.9846	.9841	.9836
		.9831	.9826	.9821	.9817	.9812	.9807	.9802	.9797	.9788	.9779
		.9758	.9753	.9735	.9716	.9698	.9677	.9653	.9629	.9604	.9580
.90											
	.3000	.3178	.3355	.3532	.3710	.3887	.4065	.4242	.4420	.4597	.4775
		.4834	.4893	.4953	.5012	.5071	.5130	.5189	.5248	.5308	.5367
		.5426	.5485	.5544	.5603	.5663	.5722	.5781	.5840	.5899	.5958
		.6018	.6077	.6136	.6195	.6254	.6313	.6373	.6432	.6491	.6550
	.9350	.9943	.9936	.9929	.9922	.9914	.9907	.9900	.9893	.9886	.9879
		.9877	.9874	.9872	.9869	.9864	.9858	.9853	.9848	.9842	.9837
		.9832	.9826	.9821	.9816	.9810	.9805	.9800	.9794	.9789	.9784
		.9774	.9755	.9737	.9718	.9693	.9675	.9651	.9627	.9604	.9580
1.05											
	.3000	.3179	.3357	.3536	.3715	.3894	.4072	.4251	.4430	.4609	.4787
		.4847	.4907	.4966	.5026	.5085	.5145	.5205	.5264	.5324	.5383
		.5443	.5503	.5562	.5622	.5681	.5741	.5800	.5860	.5920	.5979
		.6039	.6098	.6158	.6218	.6277	.6337	.6396	.6456	.6515	.6575
	.9950	.9943	.9936	.9929	.9921	.9914	.9907	.9900	.9893	.9886	.9878
		.9876	.9874	.9871	.9868	.9862	.9857	.9852	.9846	.9841	.9835
		.9830	.9825	.9819	.9814	.9809	.9803	.9798	.9793	.9787	.9782
		.9753	.9749	.9729	.9710	.9689	.9665	.9641	.9618	.9598	.9580
1.20											
	.3000	.3180	.3360	.3540	.3720	.3900	.4080	.4260	.4440	.4620	.4800
		.4860	.4920	.4980	.5040	.5100	.5160	.5220	.5280	.5340	.5400
		.5460	.5520	.5580	.5640	.5700	.5760	.5820	.5880	.5940	.6000
		.6060	.6120	.6180	.6240	.6300	.6360	.6420	.6480	.6540	.6600
	.9950	.9943	.9936	.9928	.9921	.9914	.9907	.9900	.9892	.9885	.9878
		.9876	.9873	.9871	.9866	.9861	.9856	.9850	.9845	.9839	.9834
		.9829	.9823	.9818	.9812	.9807	.9802	.9796	.9791	.9785	.9780

		.9761	.9742	.9722	.9703	.9680	.9656	.9632	.9608	.9592	.9580
1.40											
	.3000	.3182	.3365	.3547	.3730	.3912	.4095	.4277	.4460	.4642	.4825
		.4886	.4947	.5008	.5068	.5129	.5190	.5251	.5312	.5373	.5433
		.5434	.5555	.5616	.5677	.5738	.5798	.5859	.5920	.5981	.6042
		.6103	.6163	.6224	.6285	.6346	.6407	.6468	.6528	.6589	.6650
	.9345	.9831	.9817	.9804	.9790	.9776	.9762	.9749	.9735	.9721	.9707
		.9733	.9698	.9692	.9685	.9677	.9669	.9661	.9653	.9645	.9637
		.9629	.9621	.9614	.9606	.9598	.9590	.9582	.9574	.9563	.9548
		.9526	.9504	.9481	.9456	.9428	.9400	.9370	.9331	.9297	.9265
1.60											
	.3000	.3185	.3370	.3555	.3740	.3925	.4110	.4295	.4480	.4665	.4850
		.4912	.4973	.5035	.5097	.5158	.5220	.5282	.5343	.5405	.5467
		.5528	.5590	.5652	.5713	.5775	.5837	.5898	.5960	.6022	.6083
		.6145	.6207	.6268	.6330	.6392	.6453	.6515	.6577	.6638	.6700
	.9740	.9720	.9699	.9679	.9659	.9638	.9618	.9598	.9577	.9557	.9536
		.9530	.9523	.9514	.9504	.9493	.9483	.9472	.9462	.9451	.9441
		.9430	.9420	.9409	.9399	.9388	.9378	.9367	.9357	.9341	.9317
		.9232	.9267	.9240	.9208	.9176	.9144	.9107	.9055	.9002	.8950
1.80											
	.3000	.3232	.3405	.3637	.3810	.4012	.4215	.4417	.4620	.4822	.5025
		.5093	.5160	.5228	.5295	.5363	.5430	.5498	.5565	.5633	.5700
		.5768	.5835	.5903	.5970	.6033	.6105	.6173	.6240	.6308	.6375
		.6443	.6510	.6578	.6645	.6713	.6780	.6848	.6915	.6983	.7050
	.9545	.9527	.9508	.9493	.9471	.9453	.9434	.9416	.9398	.9379	.9358
		.9351	.9344	.9336	.9327	.9318	.9309	.9300	.9291	.9283	.9274
		.9264	.9252	.9240	.9228	.9216	.9203	.9191	.9179	.9164	.9145
		.9126	.9106	.9086	.9063	.9039	.9014	.8987	.8952	.8916	.8880
2.00											
	.3000	.3220	.3440	.3660	.3880	.4100	.4320	.4540	.4760	.4980	.5200
		.5273	.5347	.5420	.5493	.5567	.5640	.5713	.5787	.5860	.5933
		.6007	.6080	.6153	.6227	.6300	.6373	.6447	.6520	.6593	.6667
		.6740	.6813	.6887	.6960	.7033	.7107	.7180	.7253	.7327	.7400
	.9350	.9333	.9317	.9300	.9284	.9267	.9251	.9234	.9218	.9201	.9180
		.9173	.9165	.9159	.9151	.9143	.9136	.9129	.9121	.9114	.9107
		.9099	.9085	.9071	.9057	.9043	.9029	.9015	.9001	.8987	.8973
		.8959	.8945	.8932	.8918	.8902	.8884	.8867	.8649	.8830	.8810

MINIMUM MACH NUMBER FOR INLET DRAG CALCULATIONS .600

TABLE NUMBER 28

0.00000	.20000	.40000	.60000	1.00000	1.20000	1.60000	2.00000	-0.00000	-0.00000-0TAB 28
.85000	.95000	.97700	.98000	.98000	.97000	.94500	.90500	-0.00000	-0.00000-0

TABLE NUMBER 2C

0.00000	.70000	.80000	.90000	1.00000	1.20000	1.60000	2.00000	-0.00000	-0.00000-0TAB 2C
1.00000	.57500	.54500	.53600	.53500	.56000	.62000	.66500	-0.00000	-0.00000-0

TABLE NUMBER 2D

0.00000	1.50000	1.60000	1.80000	2.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000-0TAB 2D
0.00000	0.00000	.45000	.48400	.50000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000-0

TABLE NUMBER 2E

0.00000	.70000	.80000	1.00000	1.40000	1.60000	2.00000	-0.00000	-0.00000	-0.00000-0TAB 2E
1.00000	.67000	.65000	.62700	.62500	.63500	.70000	-0.00000	-0.00000	-0.00000-0

TABLE NUMBER 3

.62000	.70000	.80000	.90000	1.20000	1.60000	2.00000	-0.00000	-0.00000	-0.00000-0TAB 3
.40000	.50000	.60000	.65000	.66500	.68000	.70000	-0.00000	-0.00000	-0.00000-0
.11400	.25200	.31000	0.00000	0.00000	0.00000	0.00000	-0.00000	-0.00000	-0.00000-0.6
.12800	.06000	.01100	0.00000	0.00000	0.00000	0.00000	-0.00000	-0.00000	-0.00000-0.7
.14500	.07000	.01600	0.00000	0.00000	0.00000	0.00000	-0.00000	-0.00000	-0.00000-0.8
.17800	.08000	.02200	0.00000	0.00000	0.00000	0.00000	-0.00000	-0.00000	-0.00000-0.9
.25000	.14400	.05200	.01200	0.00000	0.00000	0.00000	-0.00000	-0.00000	-0.00000-01.2
.53000	.32000	.14000	.05000	.02500	0.00000	0.00000	-0.00000	-0.00000	-0.00000-01.6
.63000	.45000	.25000	.10000	.07000	.34800	0.00000	-0.00000	-0.00000	-0.00000-02.0

TABLE NUMBER 4

1.00000	1.20000	1.50000	2.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000-0TAB 4
0.00000	.02000	.04000	.06000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000-0
0.00000	.04000	.08000	.12000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000-01.
0.00000	.02750	.05500	.08200	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000-01.2
0.00000	.02250	.04500	.06750	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000-01.6
0.00000	.01700	.03450	.05100	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000-02.0

TABLE NUMBER 5

0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000-0TAB 5
0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000-0
0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000-0

TABLE NUMBER 6A

1.00000	1.20000	1.50000	2.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000-0TAB 6A
.40000	.68500	.71000	.77500	.95000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000-0
.31000	0.00000	0.00000	0.00000	0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000-0
.02400	.00200	0.00000	0.00000	0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000-0
.04400	.01000	.00700	0.00000	0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000-0
.05200	.02600	.02300	.31700	0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000-0

TABLE NUMBER 6B

0.00000	-0.00000	-0.00000	-0.10000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000-0 TAB 6B
0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000-0

TABLE NUMBER 7

0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000-0TAB 7
0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000-0
0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000	-0.00000-0

NOZZLE INPUT DECK

NOZZLE TYPE DESIGNATION	0.0	ENGINE TYPE DESIGNATION	1.0
MAXIMUM DIAMETER - IN	38.6	NOZZLE BASE OUTER DIAM - IN	0.0
OVERALL PLUG LENGTH - IN	0.0	NOZZLE BOATTAIL LENGTH - IN	23.4
NOZZLE SPACING - IN	53.8	BASE FLOW AREA - SQ IN	0.0
BOATTAIL DRAG TABLE FLAG	0.0	BOATTAIL TRAILING EDGE ANGLE - DEG	10.00
PRIMARY SPECIFIC HEAT RATIO	1.30	A10 - SQ FT	-0.00

BASE DRAG TABLE

0.00000	.60000	.80000	.90000	1.00000	1.10000	1.20000	1.60000	2.00000	-0.00000-0
1.00000	.97200	.93400	.91000	.86500	.80000	.79000	.74000	.69000	-0.00000-0

INTERFERENCE DRAG TABLE

0.00000	.55000	.75000	.85000	.95000	1.00000	1.20000	1.50000	1.80000	2.40000-0TABLE 5
1.00000	1.42000	1.53000	1.68000	2.20000	2.34000	2.40000	2.70000	3.20000	-0.00000-0
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	-0.00000-0
.00500	.01200	.00900	.00400	.00250	.00250	.00250	.00250	.00250	-0.00000-0
.00500	.01300	.01400	.00800	.00500	.00500	.00500	.00500	.00500	-0.00000-0
.00500	.01400	.01500	.01800	.00800	.00800	.00800	.00800	.00800	-0.00000-0
.00500	.01800	.02000	.02400	.03900	.03200	.03000	.02500	.02500	-0.00000-0
.00500	.02600	.02900	.03600	.05900	.06250	.05500	.03300	.02900	-0.00000-0
.01900	.01900	.01900	.01900	.01900	.01900	.01900	.01900	.01900	-0.00000-0
.00750	.00750	.00750	.00750	.00750	.00750	.00750	.00750	.00750	-0.00000-0
.00500	.00500	.00500	.00500	.00500	.00500	.03500	.00500	.00500	-0.00000-0
.00500	.00500	.00500	.00500	.00500	.00500	.03500	.00500	.00500	-0.00000-0

PCODE 0.0 NO. ENGINES 2.0 ONE CARD INPUT/POINT 2.0 2.0

MACH NUMBER 0.0000   J79-8 F4 CONFIGURATION WS/W0=.08

CASE	1.000	CASE
ALT	0.000	ALT
PS	1.000	PS
FNA	13732.990	FNA
WFT RF	29234.480	WFT RF
SFCA	2.121	SFCA
FNRF	13732.990	FNRF
FRAM	0.000	FRAM
RF	.880	RF
MILRF	1.000	MILRF
DINLET	0.000	DINLET
CDSPL	0.000	CDSPL
CDBLD	0.000	CDBLD
CDBYP	0.000	CDBYP
CDINL	0.000	CDINL
DNOZ	0.000	DNOZ
CDBT	0.000	CDBT
CDBASE	0.000	CDBASE
CDINT	0.000	CDINT
DNOZ REF	0.000	DNOZ REF
P8/P0	2.195	P8/P0
A9	651.529	A9
A8	650.252	A8
CFG	1.000	CFG
BETA	0.000	BETA
FN INPUT	17000.000	FN INPUT
WF INPUT	33221.000	WF INPUT
SFC INPUT	1.954	SFC INPUT
W INPUT	132.520	W INPUT
W ABS	132.520	W ABS
FN/DELTA	13732.990	FN/DELTA
WF COR	29234.480	WF COR
SFC COR	2.121	SFC COR
TAMB	518.690	TAMB
PAMB	2116.220	PAMB
TT0	518.690	TT0
Q	0.000	Q
ACE/AC	0.000	ACE/AC
ACI/AC	0.000	ACI/AC
A0/AC	0.000	A0/AC
STATUS	0.000	STATUS

MACH NUMBER .2000 J79-8 F4 CONFIGURATION WS/W3=.08

CASE	3.000	CASE
ALT	0.000	ALT
PS	1.000	PS
FNA	14858.495	FNA
WFT RF	32224.000	WFT RF
SFCA	2.167	SFCA
FNPF	14859.391	FNPF
FRAM	1296.558	FRAM
RF	.950	RF
MILRF	1.000	MILRF
DINLET	0.000	DINLET
CDSPL	0.000	CDSPL
CDBLD	0.000	CDBLD
CDBYP	0.000	CDBYP
CDINL	0.000	CDINL
DNOZ	42.083	DNOZ
CDBT	.039	CDBT
CDBASE	0.000	CDBASE
CDINT	.057	CDINT
DNOZ REF	21.187	DNOZ REF
P8/P0	2.218	P8/P0
A9	677.252	A9
A8	663.685	A8
CFG	1.000	CFG
BETA	11.154	BETA
FN INPUT	16200.000	FN INPUT
WF INPUT	33920.000	WF INPUT
SFC INPUT	2.094	SFC INPUT
W INPUT	192.427	W INPUT
W ABS	186.840	W ABS
FN/DELTA	14858.495	FN/DELTA
WF COR	32224.000	WF COR
SFC COR	2.167	SFC COR
TAMB	518.690	TAMB
PAMB	2116.220	PAMB
TT0	522.840	TT0
Q	59.254	Q
A0E/AC	0.000	A0E/AC
A0I/AC	0.000	A0I/AC
A0/AC	0.000	A0/AC
STATUS	0.000	STATUS

MACH NUMBER	.4000	J79-8 F4 CONFIGURATION WS/W8=.08
CASE	8.000	CASE
ALT	15000.000	ALT
PS	1.000	PS
FN	9711.681	FNA
WFT PF	21395.323	WFT PF
SFCA	2.203	SFCA
FNRF	9729.939	FNRF
FRAM	1561.468	FRAM
RF	.977	RF
MILRF	1.000	MILRF
DINLET	0.000	DINLET
CDSPL	0.000	CDSPL
CDBLD	0.000	CDBLD
CDBYP	0.000	CDBYP
CDINL	0.000	CDINL
DNOZ	66.031	DNOZ
CDBT	.030	CDBT
CDBASE	0.000	CDBASE
CDINT	.031	CDINT
DNOZ REF	47.773	DNOZ REF
P8/P0	2.414	P8/P0
A9	719.614	A9
A8	693.720	A8
CFG	1.000	CFG
BETA	10.084	BETA
FN INPUT	10130.000	FN INPUT
WF INPUT	21899.000	WF INPUT
SFC INPUT	2.168	SFC INPUT
W INPUT	131.592	W INPUT
W ABS	118.800	W ABS
FN/DELTA	17228.591	FN/DELTA
WF COR	40078.322	WF COR
SFC COR	2.326	SFC COR
TAMB	465.197	TAMB
PAMB	1192.904	PAMB
TT0	480.084	TT0
Q	133.605	Q
ACE/AC	0.000	ACE/AC
ACI/AC	0.500	ACI/AC
AC/AC	0.000	AC/AC
STATUS	0.000	STATUS

MACH NUMBER .6000 J79-8 F4 CONFIGURATION WS/W8=.08

CASE	14.000	CASE
ALT	25000.000	ALT
PS	1.000	PS
FNA	7396.865	FNA
WFT RF	16503.200	WFT RF
SFCA	2.231	SFCA
FNRF	7411.908	FNRF
FRAM	1719.667	FRAM
RF	.980	RF
MILRF	1.000	MILRF
DINLET	0.000	DINLET
CDSPL	0.000	CDSPL
CDBLD	0.000	CDBLD
CDBYP	0.000	CDBYP
CDINL	0.000	CDINL
DNOZ	52.913	DNOZ
CDBT	.025	CDBT
CDBASE	0.000	CDBASE
CDINT	.026	CDINT
DNOZ REF	67.870	DNOZ REF
P8/P0	2.677	P8/P0
A9	777.797	A9
A8	727.199	A8
CFG	1.000	CFG
BETA	8.654	BETA
FN INPUT	7650.000	FN INPUT
WF INPUT	16840.000	WF INPUT
SFC INPUT	2.201	SFC INPUT
W INPUT	180.944	W INPUT
W ABS	90.720	W ABS
FN/DELTA	19972.287	FN/DELTA
WF COR	48966.910	WF COR
SFC COR	2.452	SFC COR
TAMB	429.535	TAMB
PAMB	733.756	PAMB
TT0	460.462	TT0
Q	197.506	Q
ADE/AC	0.000	ADE/AC
ADI/AC	0.000	ADI/AC
AD/AC	0.000	AD/AC
STATUS	0.000	STATUS

MACH NUMBER	.8000	J79-8 F4 CONFIGURATION WS/W6=.08
CASE	22.000	CASE
ALT	35000.000	ALT
PS	1.000	PS
FNA	5673.291	FNA
WFT RF	12934.747	WFT RF
SFCA	2.275	SFCA
FNRF	5737.524	FNRF
FRAM	1671.990	FRAM
RF	.984	RF
MILRF	1.000	MILRF
DINLET	37.450	DINLET
CDSPL	.044	CDSPL
CDBLD	.013	CDBLD
CDBYP	0.000	CDBYP
CDINL	.058	CDINL
DNOZ	101.801	DNOZ
CDBT	.013	CDBT
CDBASE	0.000	CDBASE
CDINT	.043	CDINT
DNOZ REF	75.018	DNOZ REF
P8/P0	3.057	P8/P0
A9	865.624	A9
A8	771.312	A8
CFG	1.000	CFG
BETA	6.573	BETA
FN INPUT	5930.000	FN INPUT
WF INPUT	13114.000	WF INPUT
SFC INPUT	2.211	SFC INPUT
W INPUT	178.865	W INPUT
W ABS	69.120	W ABS
FN/DELTA	24180.239	FN/DELTA
WF COR	63117.599	WF COR
SFC COR	2.610	SFC COR
TAMB	393.874	TAMB
PAMB	496.518	PAMB
TT0	444.290	TT0
Q	222.440	Q
A0E/AC	.542	A0E/AC
A0I/AC	.547	A0I/AC
A0/AC	.542	A0/AC
STATUS	0.000	STATUS

MACH NUMBER 1.2000 J79-8 F4 CONFIGURATION WS/WB=.05

CASE	36.000	CASE
ALT	45000.000	ALT
PS	1.000	PS
FNA	5279.403	FNA
WFT RF	12315.503	WFT RF
SFCA	2.331	SFCA
FNRF	5517.351	FNRF
FRAM	2330.438	FRAM
RF	.984	RF
MILRF	.991	MILRF
DINLET	246.559	DINLET
CDSPL	.096	CDSPL
CDBLD	.019	CDBLD
CDBYP	0.000	CDBYP
CDINL	.116	CDINL
DNOZ	80.008	DNOZ
CDBT	.001	CDBT
CDBASE	0.000	CDBASE
CDINT	.038	CDINT
DNOZ REF	88.620	DNOZ REF
P8/P0	4.090	P8/P0
A9	1139.512	A9
A8	867.924	A8
CFG	1.060	CFG
BETA	1.230	BETA
FN INPUT	5580.000	FN INPUT
WF INPUT	12403.000	WF INPUT
SFC INPUT	2.223	SFC INPUT
W INPUT	178.556	W INPUT
W ABS	63.723	W ABS
FN/DELTA	36144.775	FN/DELTA
WF COR	97152.437	WF COR
SFC COR	2.688	SFC COR
TAMB	339.970	TAMB
PAMB	309.101	PAMB
TT0	502.281	TT0
Q	311.574	Q
A0E/AC	.537	A0E/AC
A0I/AC	.550	A0I/AC
A0/AC	.537	A0/AC
STATUS	0.000	STATUS

MACH NUMBER 1.6000 J79-8 F4 CONFIGURATION WS/W8=.08

CASE	46.000	CASE
ALT	35000.000	ALT
PS	1.000	PS
FNA	12317.271	FNA
WFT RF	27055.274	WFT RF
SFCA	2.197	SFCA
FNRF	13044.352	FNRF
FRAM	7471.301	FRAM
RF	.935	RF
MILRF	.962	MILRF
DINLET	795.332	DINLET
CDSPL	.107	CDSPL
CDBLD	.023	CDBLD
CDBYP	0.000	CDBYP
CDINL	.130	CDINL
DNOZ	40.533	DNOZ
CDBT	.000	CDBT
CDBASE	0.000	CDBASE
CDINT	.006	CDINT
DNOZ REF	93.783	DNOZ REF
P8/P0	6.466	P8/P0
A9	1170.214	A9
A8	812.564	A8
CFG	.998	CFG
BETA	-.012	BETA
FN INPUT	13630.000	FN INPUT
WF INPUT	27843.000	WF INPUT
SFC INPUT	2.047	SFC INPUT
W INPUT	172.430	W INPUT
W ABS	174.440	W ABS
FN/DELTA	52497.668	FN/DELTA
WF COR	132322.357	WF COR
SFC COR	2.521	SFC COR
TAMB	393.874	TAMB
PAMB	496.518	PAMB
TT0	595.537	TT0
Q	839.761	Q
A0E/AC	.598	A0E/AC
A0I/AC	.619	A0I/AC
A0/AC	.598	A0/AC
STATUS	0.000	STATUS

MACH NUMBER 2.0000 J79-8 F4 CONFIGURATION WS/W8=.08 DEC

CASE	55.000	CASE
ALT	35000.000	ALT
PS	1.000	PS
FNA	14972.637	FNA
WFT RF	34196.936	WFT RF
SFCA	2.284	SFCA
FNRF	15849.340	FNRF
FRAM	12273.013	FRAM
RF	.954	RF
MILRF	.925	MILRF
DINLET	947.109	DINLET
CDSPL	.073	CDSPL
CDBLD	.026	CDBLD
CDBYP	0.000	CDBYP
CDINL	.100	CDINL
DNOZ	31.245	DNOZ
CDBT	.000	CDBT
CDBASE	0.000	CDBASE
CDINT	.053	CDINT
DNOZ REF	131.681	DNOZ REF
P8/P0	8.241	P8/P0
A9	1170.214	A9
A8	835.164	A8
CFG	.988	CFG
BETA	-.012	BETA
FN INPUT	16730.000	FN INPUT
WF INPUT	34998.000	WF INPUT
SFC INPUT	2.096	SFC INPUT
W INPUT	139.789	W INPUT
W ABS	213.040	W ABS
FN/DELTA	63815.156	FN/DELTA
WF COR	167258.493	WF COR
SFC COR	2.621	SFC COR
TAMB	393.874	TAMB
PAMB	436.518	PAMB
TT0	728.973	TT0
Q	1323.251	Q
ADE/AC	.633	ADE/AC
ADT/AC	.663	ADT/AC
AD/AC	.632	AD/AC
STATUS	0.000	STATUS

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13. ABSTRACT

This report presents the results of a research program to develop a procedure for use in calculating propulsion system installation losses. These losses include inlet and nozzle internal losses and external drag losses for a wide variety of subsonic and supersonic aircraft configurations up to Mach 4.5. The calculation procedure, which was largely developed from existing engineering procedures and experimental data, is suitable for preliminary studies of advanced aircraft configurations. Engineering descriptions, equations, and flow charts are provided to help in adapting the calculation procedures to digital computer routines. Many of the calculation procedures have already been programmed on the CDC 6600 computer. Program listings and flow charts are provided for the calculation procedures that have been programmed. The work accomplished during the program is contained in four separate volumes. Volume I contains an engineering description of the calculation procedures. Volume II is a programmers manual containing flow charts, listings, and subroutine descriptions. Volume III contains sample calculations and sample input data. Volume IV contains bookkeeping definitions and data correlations.

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14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Afterbody Drag						
Boattail Drag						
Bookkeeping Aero-Propulsion Forces						
Boundary Layer Bleed Drag						
Bypass Drag						
Inlet Performance						
Inlet Shock Losses						
Nozzle/Afterbody Installation Losses						
Nozzle Interference Drag						
Nozzle Thrust Coefficient						
Propulsion Installation Losses						
Spillage Drag						
Subsonic Diffuser Losses						
Supersonic Inlets						
Total Pressure Recovery						

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